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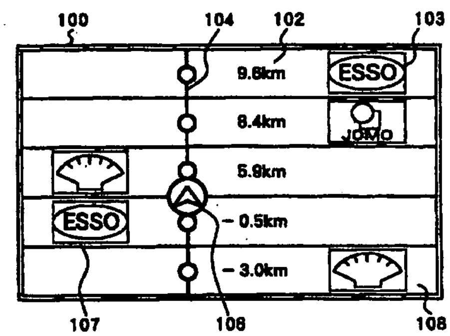
(54) Vehicle navigation system

(57) A navigator apparatus includes a map memory for storage of road map information, and a target data memory storing therein guidance information as to a destination or target object under search. A present position detector is provided for detecting a present position of a mobile vehicle. A route finder responsive to receipt of part of the map information for attempting to find out a route leading to a nearby position of the target from one of a start point of the vehicle and the present position thereof. A target searcher functions to search for a position of the target being presently stored in the target data memory in correspondence with the map information as stored in the map memory. The map information and resultant information as to the target found are both visually indicated on the screen of an associated display device while permitting voice guidance.

FIG.17



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Description

The present invention relates generally to navigation systems for directing the movement of an object so that it will reach its intended destination, and more particularly to vehicle navigation systems searching for a movement path or guidance route of a ground mobile object based on map information to provide mobile-object operators with information concerning the route. The invention also relates to vehicle navigation apparatus as enhanced in on-map searching of a surface target object and indication of the information thereof.

As one of prior art navigation systems, a vehicle navigation apparatus is described for example in Published Unexamined Japanese Patent Application (PUJPA) No. 61-194473. This vehicle navigation apparatus comes with a display device for visually indicating any part of a road map as desired by a user. The map display accompanies on the screen with presentation of several conditions required to search for an intended facility that is presently set as a destination or target point at which the vehicle aims. Hierarchical selection of several steps of conditions may allow the user to finally identify the facility s/he want to reach. The location of such identified facility is then displayed by use of an identification mark on the map display screen. In addition, one recommendable movement path or route from a present position is searched for by the navigation apparatus based on the map information to be displayed simultaneously. Note here that while the mobile object, here vehicle, is travelling along the path of such recommended guidance route, necessary surface environmental information may be given to the user by means of audible presentation schemes such as guidance voices.

With the navigation apparatus, it will possibly happen that the user changes his or her mind on the way of the movement route or at a nearby point of the vehicle's present position to prefer to visit a facility other than the target place once determined earlier; for example, a place to eat, to refuel, or the like. In the case where the user happens to want to stop at a facility excluding the target place, it is required that such temporal "stop-at" place be again designated through iterative search operations based on the map information. The search operations nay be similar to those in the initial entry of target place under substantially the same search conditions, which may include designation of genre alike.

The genre being designated may involve a gas station, restaurant, etc. Since the movement objective to stop at such facility is clear, selection is done in order to extract only those of limited facilities which meet the objective. One example is that the objective of stopping at such place is to refuel the vehicle. If this is the case, genre designation is made to search for gas stations only. In this way, once after the genre is designated, a plurality of facilities belonging to such genre will be found and extracted.

In the prior art navigation apparatus the linear distance toward each facility extracted is visually indicated on the display screen. Note however that any relative positional relation of the user's vehicle and the facility remains indeterminate before an image of the exact "stop-at" facility is displayed on the map display screen. Especially, the prior art fails on some occasions to specifically indicate the geographical positional relationship with a recommended movement route as presently searched by the navigation apparatus. This makes it difficult for the user to promptly figure out which one of the presently displayed facilities perfectly matches his or her desired one.

It is therefore an object of the present invention to provide an improved navigation apparatus capable of avoiding the problems encountered with the prior art.

To achieve the foregoing object, the present invention provides a navigation apparatus including a map information storage device for storing therein map information, a target data storage device for storing guidance information as to a target object under request, a present position detector device for detecting a present position of a mobile vehicle, a route finder device responsive to receipt of part of the map information as stored in the map information storage device for attempting to find out a path or route leading to a nearby position of the target from one of a start point of the vehicle and a present position thereof, a target search device for searching for a position of the target being presently stored in the target data storage device in a one- to-one correspondence manner with the map information as stored in the map information storage device, and an output device for providing the map information and information on the target as found by the target search device.

In accordance with another aspect of the invention, there is provided a navigation apparatus including a map information memory for storing therein map information, a present position detector for detecting a present position of a vehicle, a route finder for attempting to search, based on the map information stored in the map information memory, for a route leading to a nearby position of a target location from one of a position near a present position detected by the present position detector and a position near a start point of the vehicle, a target input device for allowing entry of a desired target object, a target search device for searching for an input target through the target input device from the map information as stored in the map information memory, a schematic diagram preparation device responsive to a route searched by the route finder and a target searched by the target search device for producing a schematic diagram indicative of a positional correlation of the route and the target, and an output device for generating and issuing the schematic diagram provided by the schematic diagram preparation device.

In accordance with a further aspect of the invention, a navigation apparatus includes a map information memory for storage of map information, a route finder responsive to receipt of the map information stored in

the map information memory for searching for a route leading to a target point from one of a start point of a vehicle and a nearby point of a present position of the vehicle, a target searcher for searching for a position of the target in correspondence with the map information stored in the map information memory, a target identifier for determining on which side of a route being searched by the route finder a target exists while this target is presently searched by the target searcher, and an output device for providing "which-side" information relating to a resultant side on which the target exists with respect to the route as identified by the target identifier.

These and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings.

Fig. 1 is a block diagram showing an overall configuration of a navigation apparatus in accordance with one preferred embodiment of the present invention.

Fig. 2 is a diagram showing a data structure as stored in a data storage unit 38c of an information memory section 37 in the navigation apparatus.

Fig. 3 is a diagram showing the content of a facility data file F16.

Fig. 4 is a diagram showing data stored in a RAM 5.

Fig. 5 is a diagram showing the structure of a road data file F4.

Fig. 6 is a diagram showing a positional correlation of a guidance route and a facility.

Fig. 7 is a diagrammatic representation for explanation of right/left position detection of each facility with respect to the route-travel direction.

Fig. 8 is a diagrammatic representation for explanation of a minimum linear-distance calculation procedure of each searched facility and guidance route.

Fig. 9 is a flow diagram of the main control procedure of the navigation apparatus.

Fig. 10 is a flow diagram of a nearest-facility processing routine.

Fig. 11 is a flow diagram of a nearest-facility searching routine.

Fig. 12 is a flow diagram of a routine of extraction of a certain facility located along the route.

Fig. 13 is a flow diagram of a routine of the minimum linear distance between a facility and guidance route.

Figs. 14 and 15 are each a flow diagram of a routine of indication of a certain "along-the-path" facility located along the guidance route.

Fig. 16 is a flow diagram of a routine of indication of all of the facilities available.

Fig. 17 is a diagram showing one exemplary indication of a list of facilities along the route.

Fig. 18 is a diagram showing an exemplary indication of a list of genre selection for use in searching for an aimed facility.

Fig. 19 is a presentation of an exemplary route resulted from the route search made by the navigation apparatus embodying the present invention.

Fig. 20 is a diagram showing several possible indication examples, including a guidance display on the way of the route, and point-search indication of a gas station all being available in the navigation apparatus of the invention.

Fig. 21 is a flow diagram of a guidance display/point search display control procedure of the navigation apparatus.

Fig. 22 is a diagram showing an exemplary road network as processed by the navigation apparatus.

Fig. 23 is diagrammatic representation for explanation of a road junction or intersection as processed by the navigation apparatus.

Fig. 24 is a diagram showing the road network and route search data of the navigation apparatus.

Figs. 25 and 26 are illustrations showing in configuration several road data items of the navigation apparatus.

Fig. 27 is a flow diagram of a principal control procedure of the navigation apparatus embodying the invention.

1. Overview of Embodiments

One preferred embodiment of the present invention as will be described below is a navigation apparatus which features in some functions that follow: searching for a target object as externally input thereto from map information (see a step SC6 shown in Fig. 11), selectively extracting, based on the map information concerning the resulting searched target object, one or more target objects being located along a searched route leading to a nearby position of the target from a nearby position of either the vehicle's start point or a present position thereof (see step SD2 of Fig. 12), and generating and issuing information as to a resultant target object being selectively extracted.

It should be noted that an embodiment described later is also a navigation apparatus which features in several functions as follows: searching based on the map information for an appropriate or best-suited guidance route leading to a nearby position of a target point from a nearby position of either the vehicle's start point or its present position (a route search processing at a step SA4 in Fig. 8), searching for an externally input target object from the map information (at step SC6 if Fig. 11), selectively extracting based on the map information as to the resulting searched target object one or more target objects located along the searched route (at step SD2 of Fig. 12), and outputting information on a selectively extracted target object(s) (at steps SE4, SE11 of Fig. 14 and at step SF1 in Fig. 15, also relating to a speaker 13).

It should be also noted that the navigation apparatus embodying the invention features in that it operates to: search based on the map information for a route leading to a nearby position of a target point from a nearby position of either the vehicle's start point or a present position thereof (a route search processing as

shown at step SA4 in Fig. 8), search based on the map information and the resulting searched route for an externally input target object (at step SC6 in Fig. 11 and at step SD2 of Fig. 12), and provide information as to this searched target object (at steps SE4, SE11 of Fig. 14 and at step SF1 of Fig. 15, also concerning speaker 13).

It should be further noted that the navigation apparatus embodying the invention includes a map information storage device (corresponding to an optical recording medium of a magnetic recording medium such as a floppy diskette drive module as arranged in an data storage section 37) for prestoring therein map information, a present position detector that detects a present position of a mobile vehicle (at step SA2 of Fig. 9), a route finder that searches, based on the map information as stored in the map information storage device, for a route toward a nearby position of a target point from a nearby position of either the vehicle's present position as detected by the present position detector or the vehicle's start point (the route search processing shown at step SA4 of Fig. 8), a target input device that allows entry of any desired target object (at steps SC1 to SC3 in Fig. 11), a target searcher that searches for the target object as inputted by the target input device from the map information stored in the map information storage device (at step SC6 of Fig. 11 and step SD2 of Fig. 12), a distance calculator for calculating or computing a distance between the target searched by the target searcher and the present position as detected by the present position detector (at step SD2 of Fig. 12), a schematic diagram drafter for preparing-based on the present position detected by the present position detector, position data of the target object detected by the target searcher, and the distance as calculated by the distance calculator-a schematic diagram that indicates the positional correlation of the present position and the target object (at step SF1 in Fig. 15), and an output device (corresponding to a display 33 or speaker 13) for generating and issuing the resulting schematic diagram as provided by the schematic diagram drafter.

It should be still further noted that the navigation apparatus embodying the invention may alternatively include a map information storage device (corresponding to an optical recording medium or a magnetic recording medium such as a floppy diskette drive module as arranged in data storage section 37) for prestoring therein map information, a route finder for searching, based on the map information as stored in the map information storage device, a route toward a nearby position of a target point from a nearby position of either the vehicle's present position or the vehicle's start point (the route search processing shown at step SA4 of Fig. 8), a target input device for allowing entry of any desired target object (at steps SC1 to SC3 in Fig. 11), a target searcher for searching for the target object as inputted by the target input device from the map information stored in the map information storage device (at step SC6 of Fig. 11), a target selector for selecting from among target objects searched by the target searcher any target object(s) being located within a predefined range from the route searched by the route finder (at step SD2 of Fig. 12), a distance calculator for calculating a distance between the target object selected by the target selector and a present position of the vehicle (at step SD2 of Fig. 12), a schematic diagram drafter for preparing-based on the route searched for by the route finder, position data of the target object detected by the target searcher, and the distance as calculated by the distance calculator-a schematic diagram that diagrammatically represents the positional correlation of the searched route and the target object (at step SF1 in Fig. 15), and an output device (corresponding to display 33 or speaker 13) for generating and issuing the resultant schematic diagram as provided by the schematic diagram drafter.

It should be yet further noted that the navigation apparatus embodying the invention may alternatively be constituted from a map information storage device (corresponding to an optical recording medium or a magnetic recording medium such as a floppy diskette drive module as arranged in data storage section 37) for prestoring therein map information, a route finder that searches, based on the map information as stored in the map information storage device, for a route toward a nearby position of a target point from a nearby position of either the vehicle's present position or the vehicle's start point (the route search processing shown at step SA4 of Fig. 8), a target searcher for searching for the position of a target object (stop-at facility) in correspondence with the map information as stored in the map information storage device (a random access memory or RAM 5, and step SC4 in Fig. 11), a target identifier for determining whether the target object being stored in the target searcher is present within a predetermined range of the route as searched by the route finder (at step SD2 of Fig. 12), and an output device (corresponding to a display 33 or speaker 13) for generating and issuing resultant information as to the target as identified by the target identifier (at steps SE4, SE11 in Fig. 14 and at step SF1 of Fig. 15, also pertinent to speaker 13).

One feature of the navigation apparatus is that the target along a path or route searched involves one falling within a predefined range from the route along which the vehicle has already traveled, and in that the schematic diagram drafter or the target identifier also processes the target within the predefined range for either preparation of a corresponding schematic diagram or identification thereof (at step SD2 of Fig. 12 and at step SE2 of Fig. 14).

Another feature of the navigation apparatus is that it further includes a selective target extractor (extraction conditions regarding environment of roads neighboring a target object) for selectively extracting a specific target from those stored in the target searcher, thereby allowing selective extraction, selection and identification of the target to be attained by determining whether the tar-

get as selectively extracted is within the predefined range from the searched route.

Still another feature of the navigation apparatus is that the selective target extractor attempts to selectively extract the specific target based on the type (or kind), identification, classification, field, objective, use, business content, and geographic relationship between the target and a present position (including the distance between the target and present position, and the direction of the same).

Yet another feature of the navigation apparatus is that it calculates a distance from a present position to the target as identified by the target identifier (at step SE2 of Fig. 14), and to visually or audibly indicate a resultant calculated distance up to the target (using display 33 or speaker 13).

It should be further noted that the navigation apparatus embodying the invention may be comprised of a map information storage device (data storage section 37) for storing therein map information, a route finder responsive to receipt of the map information stored in the map information storage device for searching for a route leading to a target point from a nearby position of either the start point of a vehicle or a vehicle's present position (route search processing at step SA4 in Fig. 9), a target searcher (first RAM 5, step SC4 of Fig. 11) for searching for the position of the target (geographic coordinates of each "stop-at" facility) in correspondence with the map information stored in the map information storage device, a target identifier for determining that a target being presently searched by the target searcher exists on which side of a route as searched by the route finder (at step SD3 in Fig. 12), and an output device (display 33 or speaker 13) for providing information as to a certain side on which the target exists with respect to the route as identified by the target identifier.

It should be still further noted that the navigation apparatus may come with a map information storage device (corresponding to an optical recording medium or a magnetic recording medium such as a floppy diskette drive module as arranged in data storage section 37) for prestoring therein map information, a target searcher that searches for the position of a target object (stop-at facility) in correspondence with the map information (geographic coordinates of each stop-at facility) stored in the map information storage device (at RAM 5 and step SC4 of Fig. 11), a point setter for setting a certain point(s) acting as a reference (points X0, Y0 in Fig. 7), a direction setter for setting a certain direction (vector a of Fig. 7) as a reference from the certain point as set by the point setter, an orthogonal direction setter for setting an orthogonal direction (vector c of Fig. 7) with respect to the direction as set by the direction setter, an inner-product calculator for calculating or computing a vector inner product ($|b| \times |c| \times \cos\theta$) of the orthogonal direction set by the orthogonal direction setter and the direction from the reference point set by the point setter toward the target object searched by the target searcher, a target identifier for determining based on the calculation result of the calculator that the direction of the target object is present on which side of the reference direction (at step SD13 of Fig. 12 of judging which polarity the inner product has, i.e., positive or negative), and an output device (display 33 or speaker 13) for generating and issuing the direction of target object as determined by the target identifier.

It should be yet further noted that the navigation apparatus embodying the invention may include a map information storage device (corresponding to an optical recording medium or a magnetic recording medium such as a floppy diskette drive module as arranged in data storage section 37) for prestoring therein map information, a route finder responsive to receipt of the map information stored in the map information storage device for searching for a route leading to a target point from a nearby position of either the start point of a vehicle or its present position (route search processing at step SA4 in Fig. 9), a target searcher for storing therein the position of a target object (stop-at facility) in correspondence with the map information (geographic coordinates of each stop-at facility) stored in the map information storage device (at RAM 5 and step SC4 of Fig. 11), a distance calculator for calculating a distance from the route searched by the route finder toward the target object as stored in the target searcher (at step SD2 of Fig. 12), and an output device (display 33 or speaker 13) for generating and issuing the distance between the route and target object as calculated by the distance calculator.

2. Entire Circuitry

Fig. 1 shows overall configuration of a navigator apparatus embodying the invention. A central processor 1 is provided as a main controller that controls the entire operations of the navigation apparatus. This controller 1 is constituted from a central processing unit (CPU) 2, a nonvolatile semiconductor memory 3 which may be an electrically erasable programmable read only memory (EEPROM) such as " flash" EEPROM, a ROM (ROM #2) 4, a first random access memory (RAM) 5, a second RAM 6, a sensor data input interface 7, a communication interface 8, an image processor 9, an image memory 10 such as a video RAM (VRAM), an audio processor 11, and a clock 14. All of the components 2-14 are operatively connected together via a CPU local bus 15 allowing several kinds of data or information to be transferred and received there among under the control of CPU 2.

The flash EEPROM 3 receives a program module 38b prestored in a data storage unit 37 to store the same therein. The program module 38b contains those based on which CPU 2 executes several kinds of tasks in accordance with respective ones of predefined control procedures as will be presented later, such as display control of information and voice guidance control, for example.

The information stored in the flash EEPROM 3 may

also involve different kinds of parameters for use in navigation control operations. ROM 4 stores therein both graphic display pattern data and several kinds of general-purpose data. The term "display graphic pattern" is intended to mean any data required for accomplishment of route guidance to be visually indicated on the screen of a display unit 33. The " general-purpose data" refers to each data as used during navigation, such as voice wave data which may be playback information of electronic synthesis guidance voices or human voice prerecorded.

The first RAM 5 acts to temporarily store therein input data supplied externally, several kinds of parameters, arithmetic result and navigation program modules. The clock 14 generally consists of a counter, a RAM or an EEPROM for battery backup, and serves to generate and issue time information at its output.

The sensor input interface 7 includes an analog-to-digital (A/D) converter circuit, a buffer circuit, or the like. Interface 7 is electrically connected to a respective one of several sensors as provided in a present position detector device 20, and operates to receive at inputs sensor data as transmitted therefrom in an analog or digital signal format. The sensors of present position detector 20 are an absolute direction sensor 21, a relative direction sensor 22, a distance sensor 23, and a vehicle speed sensor 24.

The absolute direction sensor 21 may be a geomagnetism sensor that detects the earth magnetism to generate at its output a corresponding detection data indicative of the North and South directions defining the absolute directions. Relative direction sensor 22 may be a steering angle sensor, which cooperates with a presently available optical gyroscope-including an optical gyro, a piezoelectric vibration gyro alike-to detect the actual steering angles of wheels of an automobile vehicle associated therewith. Sensor 22 functions to generate and issue at its output the detected relative angle in the vehicle's travel direction with respect to the absolute direction as detected by absolute direction sensor 21.

The distance sensor 23 may consist of a counter operatively associated with a known odometer of the vehicle. Sensor 23 operates to output certain data representative of the vehicle's travel distance measured. The speed sensor 24 typically consists of a counter as connected to a known speedometer. Sensor 24 outputs data proportional in value to the running speed of the vehicle.

The communication interface 8 of controller 1 is also connected to an input/output (I/O) data bus 28, which in turn is operatively coupled to a global positioning system (GPS) receiver device 25, a beacon receiver device 26 and data receiver device 27 in the present position detector 20. Further connected to I/O data bus 28 are an electronic " touch" panel 34 with a transparent pad sheet, a printer unit 35 and information storage unit 38, all of which are arranged in an I/O device 30. Communication interface 8 thus arranged above may enable several kinds of data to be transmitted between respective associated devices and CPU local bus 15.

The present-position detector 20 provides at its output data for use in detecting a present position of the travelling vehicle. More specifically, absolute direction sensor 21 detects the absolute direction; relative direction sensor 22 detects a relative direction with respect to the absolute direction detected; distance sensor 23 senses the vehicle's travel distance; and, speed sensor 24 detects the running speed of the vehicle. GPS receiver 25 receives signals-namely, microwaves as transmitted from a plurality of GPS satellites each in an orbit around the Earth-for detection of geographic position determination data including latitude and longitude position data of the vehicle.

Likewise, the beacon receiver 26 receives beacon waves as transmitted from the vehicle information and communication system (VICS), and provides I/O data bus 28 with either certain nearby road traffic information or GPS's correction data. The data transmission/reception (TX/RX) device 27 acts to deal with transmission and reception of any required information, including voice communication signals of handheld cellular phones, frequency-modulation (FM) multiplexed signals, while allowing the present position information or the information as to road transportation conditions in the surrounding or "nearby" area around the vehicle's present position to be transmitted to and received from the existing two-way present position information providing system or advanced traffic information service (ATIS) using the public telecommunication networks. Such information may be used as either vehicle's present position detection information or as auxiliary information therefor. Note here that beacon receiver 26 and data TX/RX 27 may be omitted if needed.

The I/O device 30 includes a speaker unit 13 in addition to display unit 33, touch panel 34 and printer 35, display unit 33 functions to display on its screen necessary guidance information for the user-e.g., a driver of the vehicle-during navigation operations. Touch panel 34 is attached on the display screen of display unit 33 in such a manner that a plurality of rows and columns of "touch" switches are organized into a plan or two-dimensional matrix form. The touch switches may be contact switches using transparent electrodes, piezoelectric switches, or other equivalent elements. Using touch panel 34 allows selective entry of necessary information for target point settings, such as the vehicle's departure or start point, driver's preferred destination or target point, pass-through or transit points in a route leading to the target, and others.

The printer 35 operates to provide hard-copies of several kinds of information as required, involving a map picture as output via communication interface 8, a facility guide, etc. The speaker 13 may provide the driver with respective audible guidance information as preferred. Printer 35 is omittable.

The display unit 33 may be constituted from any one of presently available image displayable devices, such as a cathode-ray tube (CRT), liquid crystal display

(LCD) panel, plasma display (PD) panel or the like. LCD may be preferable in this case due to its several advantages -less power consumption, relatively high visibility, and light weight. The LCD panel 33 is operatively associated with the image processor 9, which in turn is connected to VRAM 10 that may be a dynamic random access memory (DRAM) or dual-port DRAM. Image processor 9 provides controls over writing or programming of image or video data into VRAM 10. Processor 9 also acts to control display operations of any readout video signals as read out of VRAM 10 on the screen of LCD panel 33.

The image processor 9 is responsive to illustration draft command signals as fed from CPU 2, for converting map information and character data into corresponding image data for display to write or program them into VRAM 10. At this time, additive peripheral images being displayed on LCD 33 for scroll are also prepared and programmed in VRAM 10 simultaneously.

The speaker 13 is connected to audio processor 11, which is in turn coupled via the CPU local bus 15 to CPU 2 and ROM 4. Audio-wave data for guidance voice generation as read from ROM 4 are input to audio processor 11. Such audio-wave data are converted by processor 11 into a corresponding analog audio signals, which will be reproduced at speaker 13. Note that audio processor 11 and image processor 9 may be general-purpose digital signal processors (DSPs).

The information storage unit 37 may be constituted from not only an optical memory such as a compact disc read-only memory (CD-ROM) but also any one of other types of devices; for example, an integrated circuit (IC) memory, a semiconductor memory such as an IC card, a magneto-optical disk drive module, a magnetic recording device such as a fixed disk or "hard disk" drive unit. Where the recording media or device in information storage unit 37 is changed, data TX/RX device 39 is also modified to has an appropriate data pickup tool adaptable for such device changed. One example is that when the storage device is a hard-disk drive, data TX/RX 39 comes with a read/write device for allowing magnetic signals to be read from or written onto an associative magnetic disk(s), which may be a core head.

The information storage unit 37 has a data storage space, which is subdivided into plural portionsthree blocks 38a, 38b, 38c in the illustrative embodiment. The block 38c is for storage of essential data as required to execute navigation operations, which data may include map information, road-junction/intersection data, node data, road data, picture data, destination/target-point data, guidance point data, detailed target data, target point read data, house/building shape data, and others. Block 38b of information storage unit 37 is to store therein a set of software program modules, which make use of road map information as scored in block 38c to execute navigation operations as required. Note here that the navigation execution program set 38b is read by data TX/RX 39 from information storage unit 37 to be programmed into flash EEPROM 3 for later use. The remaining data may include guidance indication data, voice guidance data, schematic/abstractive guidance-route image data, etc.

The information storage unit 37 may selectively store in block 38c as the map information corresponding to a plurality of contraction scales and/or map information with the minimum scale. Accordingly, in case where a map with a greater contraction scale is displayed on LCD 33, it is permissible that some information are partly subtracted or " thinned" from the map information of the minimum scale in data block 38c of information storage unit 37. During display of the map information contraction scale of block 38c, the geographic distance of each road is reduced in scale while simultaneously causing indication mark/symbol information concerning one or several facilities to be partly subtracted therefrom.

3. Data Files of Data 38c in Storage Unit 37

Fig. 2 depicts a configuration of the data block 38c of the information storage unit 37, which consists of sixteen data files F1 to F17, by way of example. The contents of these data files are as follows. The data file F1 is a map information file for storage of map information involving national road maps, local road maps, city/town maps, etc. The data file F2 is for storing data as to road junctions or intersections each associating with geographic position coordinates and its title/name or identification (ID). Data file F3 contains geographic coordinate data of each node for use in route search on a map. Data file F4 is a road data file which stores therein specific data representative of road/street positions, kinds and lane numbers along with connection relationship there among. Data file F5 is a photographic picture data file that stores therein picture image data of respective kinds of facilities and points of interest worse to visit or of any other places as required for visual indication or presentation, such as the major intersections alike.

The data file F6 is a target point data file that stores therein data as to specific places or facilities that will possibly be frequently subject to search as drivers' destination or target point, including the major sightseeing places or buildings, and enterprises or cooperative offices as listed up in public telephone directory books, along with the locations and titles/names thereof. Data file F7 is a guidance point data file F7 which stores several guidance data regarding certain points under request for guidance, including the contents of road signs or public guidance indication plates and/or nodes. Data file F8 is a detailed target point data file which stores therein detailed data concerning the target points as stored in target point data file F6. Data file F10 is a road name data file which contains road-name data of major roads or streets as selected from among those stored in road data file F4. Data file F11 is the one for storage of a number of identification (ID) data of major

target points. Data file F12 stores list data for use in searching for any desired one of target points as stored in data file F6 based on address thereof.

A out-of-town/local phone number list file F12 stores therein list data of only the out-of-town/local phone number parts of target points as stored in data file F6. A registered phone number data file F13 stores phone number data being additionally registered through operator' s manual operations, including phone numbers of interest such as those of customers on business. A mark data file F14 stores data as to positions and IDs of characteristic points each serving as an eye-catch mark along route and those of places of interest which are input through operator's manual operations. A point data file F15 stores detailed data of any one of mark points as stored in data file F14. A facility data file F16 stores data concerning positions and associated explanation of any possible places the driver wants to stop in excluding his or her presently intended target point, such as a gas station, a convenience store, a parking area, etc.

4. Facility Data File

Fig. 3 depicts a data structure of the facility data file F16 as stored in data block 38c of information storage unit 37. This file F16 contains therein information as to a preselected number say, SS(n)of facilities. Each facility may represent a target object set as the stop-at place alike, as described previously. One item of such facility data consists of a genre number SJN, north latitude coordinate SNO, east longitude coordinate SEO, mark number SPN and name/title SN.

The genre number SJN indicates the genre to which a facility belongs. Where the facility of interest is an eating place such as a hamburger shop, its genre number indicates the category of family restaurant/fast-food. In other words, the genre number SJN represents any corresponding facility kind that allows facilities to be organized into groups in accordance with the driver's objective of stopping at or dropping in an intended facility. Genre number SJN may also contain additive data for identifying the kind, classification, genus, field, aim, use, business content of each facility such as a sight-seeing place, recreation facility (involving a skiing ground, for example), gas station, department store, parking area or the like and geographic correlation of the vehicle and a selected facility. This geographic correlation indicates the distance between the vehicle and a presently selected target object, the direction of such target object from the vehicle, and others.

Each facility can be identified in geographical position on a map by use of a combination of the north latitude and east longitude coordinates SNO, SEO. An identification (ID) symbol of each facility is designated by the mark number SPN. This ID symbol means a mark that facilitates easy identification of the genre (business content) or the like of each facility being presently selected when it is to be displayed on the screen. The determinate name/title of each facility is represented by the name/title identification SN. The determinate name/title refers to a widely recognized public name or title for identification, such as New York Municipal Office, Yankee Stadium, or the like.

5. Data Content of First RAM 5

Fig. 4 shows part of the data set as stored in the RAM 5. Present position data MP represents a present position of the vehicle which is detected by the present position detector 20 of Fig. 1. Absolute direction data ZD indicates the north-to-south direction to be obtained based on the information from absolute direction sensor 21. Relative direction data D is angular data indicative of an angle of the vehicle' s running direction with respect to absolute direction data ZD. This relative direction angle (azimuth) data D is obtained based on the information from relative direction sensor 22.

Travel distance data ML represents the actual distance the vehicle has passed, which is obtained based on data from distance sensor 23. Present position information PI is data regarding a present position, which may be entered by way of either beacon receiver 26 or data TX/RX 27. VICS data CD and ATIS data AD are those as input from either beacon receiver 26 or TX/RX 27. Utilizing VICS data VD may enable execution of error correction on the vehicle's position as detected by GPS receiver 25. Also, using ATIS data AD permits proper identification of traffic regulation and traffic density in an area of interest.

Registered target point data TP contains data as to any one of driver's registered target points along with the coordinate position and name/tile thereof. Guidance start point data SP includes the map coordinate data of a specific point at which the navigation operation gets started. Similarly, final guidance point data ED contains the map coordinate data of a point whereat the navigation operation is terminated.

Guidance start point data SP may make use of coordinates of a node on a guidance road that is the nearest one to either the vehicle's present position or the start point. The reason for storage of such guidance start point data SP is that a present position of the vehicle will not necessarily be on the guidance road, and the present position may be happened to be in an area or site off from the road, such as a golf club, parking area, or the like. Regarding final guidance point data ED also, the coordinates of the nearest on-the-road node to a corresponding registered target point TP is stored therein. The reason for storage of such data ED is similar to the preceding one in that the coordinates of registered target point data TP will be possibly happened to be absent on the road. Guidance route data MW as stored in the first RAM 5 is the data expressly indicating an optimal or recommended route leading to a target point, which route is obtained through the route search processing at step SA4 to be described later. Note that each road on the road map stored in data block 38c of

information storage unit 37 is added with a corresponding road number being inherent thereto. Guidance route data MW is constituted from an array of road number data groups covering from guidance start point data SP to final guidance point data ED, as will be discussed later.

Mode set data MD is the data adaptable for use in a target facility setting procedure to be described later. Mode set data MD is settable by use of the touch-switch panel 34 laminated on LCD 33 shown in Fig. 1. Mode content being displayed on LCD 33 may be selected using mode set data MD.

Beep point data BP contains therein set data as to a stop-at facility as selected by a nearby facility processing as will be explained later. Similarly, search facility number GB(n) stores therein the identification (ID) number of a respective one of a plurality of facilities as presently searched by the nearby facility processing. The ID number may correspond to a variable n in facility data file F16. Facility-to-target distance data Zn stores therein a distance from each facility designated by its search facility number GB toward final guidance point data ED along the guidance route thereof. The facility-to-target distance Zn will be described in more detail later in connection with its accompanying flow diagrams.

Vehicle-to-facility distance data Wn stores therein a distance value as calculated at an along-the-path facility display processing step to be discussed later. The vehicle- to-facility distance Wn represents a relative distance from a present position of the vehicle. Vehicle-to-facility distance Wn will be used when a list of stop-at facilities located along the guidance route is visually indicated on the screen of LCD 33. Right/left data RL indicates whether each extracted facility is on the right hand or the left hand side with respect to either the guidance route or vehicle's present position. Specifically, right/left data RL points out on which (right or left) side each extracted facility is present under the condition that the vehicle has moved forward in the direction of target point along a guidance route as presently searched at step SA4, or in the direction that the vehicle is running.

6. Road Data

Fig. 5 shows part of the road data included in the road data file F4 stored in information storage unit 37. This file F4 contains information as to all of the roads or streets that are present within a range as stored in the map data file and are of more than a predefined width. Letting the number of roads contained in road data file F4 be " n," the road data concerning the individual one of such n roads are contained therein, while respective road data consists of road number data, guidance object flag, road attribute data, shape data, guidance data and length data.

The road number data is an ID number being individually added to each road which is subdivided from all the roads included on the road map. The guidance object flag is a "1" when it is a guidance object road, or a "0" when a non- guidance object road. Note here that the " guidance object road" refers to a relatively wide road having width greater than a predetermined width-such as trunk roads or local roads/streets-which is selectable as a route search object during navigation operations. The "nonguidance object road" refers to a relatively narrow street or path such as footpath, alley or lane, which will not act as any object under route search.

The road attribute data is the one representative of road attributes involving an elevated read or "overpass," an underground road or "underpass, " highway, turnpike, and the like. The shape data represents the shape of each road by storage of coordinate data of a road start point, a road termination point, and a node between the start and termination points. The coordinate data of each node has been stored therein as the shape data together with the coordinate data of start and termination points.

The guidance data consists of road-junction or intersection ID data, caution data, road ID data, road ID audio data and destination data The intersection ID data may represent the name or title of an intersection which acts as the termination point of a specified road. The caution data is the one representative of caution or notice at a point on the road, such as a railroad crossing, tunnel entrance, tunnel exit, road-width reduction point, or the like. The road ID audio data is audio data indicative of any one of road IDs for use in audio/voice guidance.

The destination data is the one regarding one or several roads connected to the termination point of road-assume each as a destination -and consisting of a destination number k and data of an individual one of destination points. The destination data may consist of destination road number data, destination ID data, destination ID audio/voice data, destination direction data and run guidance data.

The road number of a destination point is indicated by use of the destination road number data. The name/title of a destination road is indicated by the destination ID data. The destination ID audio data contains audio data as required to attain voice guidance of a name/title of destination. The destination direction data is used to show the direction in which the destination road extends. The run guidance data contains guidance data being stored therein for providing guidance to approach an intended destination road, which guidance may include voice speeches "change the lane to the right," "change the lane to the left," or "continue running in the center lane." The length data is indicative of the length of the start and termination points of a road, the length from the start point to each node, and the length between adjacent nodes.

7. Overall Control Procedure

Fig. 9 shows a flowchart of the overall control processing procedure to be executed by the CPU 2 of the navigation system embodying the present invention. This procedure gets started upon power-up and will end when power is turned off. The turn-on/off of power may be done in response to the on/off of the navigation system per se or of an engine start key (ignition switch).

The control procedure of Fig. 9 goes to step SA1 for execution of an initialization processing as follows. First, an associated navigation software program is read out of the data block 38c of information storage unit 37 causing a copy thereof to be loaded into flash EEPROM 3. The loaded program in EEPROM 3 is then executed. Next, CPU 2 attempts to erase or "clear" the general-purpose data storage area in each of associative RAMs, including the work memory of RAM 5 and VRAM 10.

Subsequently, the procedure of Fig. 9 executes cyclically a series of processing tasks as defined at the steps that follow: a present position processing step SA2, target point set processing step SA3, route search processing step SA4, guidance/display processing step SA5, nearby facility processing step SA6, and other task processing step SA7. While there is no alternation of target point or no removal of the vehicle from a presently guided route, the steps SA3, SA4 will not be carried out in an overlapped manner.

When control goes to step SA2, CPU 2 attempts to detect the geographic coordinates (longitude, latitude, and height) of the vehicle as a ground mobile object with the navigation system build therein. This may be accomplished by receiving signals transmitted from a plurality of GPS satellites each of which is in an orbit around the Earth. Based on radio waves from respective satellites, there are sensed the coordinate position of each satellite, the radio wave transmission time at each satellite, and the radio wave reception time at the GPS receiver 25 of Fig. 1. The resulting information may be used to determine by appropriate computation the exact distance between the vehicle and each satellite. The resultant satellite distance data is then used to compute the coordinate position of the vehicle thus acquiring a present position thereof on a read-time basis. The acquired vehicle's present position is stored in the first RAM 5 as the present position data MP. Occasionally, the present position data MP can be partly modified or changed depending upon the information as input from beacon receiver 26 or data receiver 27.

Also at the present position processing step SA2, the absolute direction data ZD, relative azimuth data D and travel distance data ML are calculated by use of the absolute direction sensor 21, relative direction sensor 22 and distance sensor 23 shown in Fig. 1. Data ZD, D, ML are then used to perform arithmetic processing for specifying a present position of the vehicle. The resulting vehicle's present position thus calculated is then compared with the map information being stored in data block 38c of information storage unit 37 to be suitably corrected as necessary to ensure that the present position is accurately displayed on the map screen. With such correction, it becomes possible to attain accurate computation of the vehicle's present position even under occasions where the vehicle happens to be in a tunnel disenabling proper reception of any GPS signals.

At the target point set processing step SA3 shown in Fig. 9, the geographic coordinates of a target point as desired by the operator is set as the registered target point data TP. For example, such data is designated by the operator who sets the coordinate position of his or her desired target object while looking at a road map or city map being presently displayed on the screen of LCD 33. Alternatively, such target object may be identified by the operator by selection from an item-based list of target object candidates to be displayed on LCD 33. Upon completion of the operator's designation of one specific target point, CPU 2 controls RAM 5 causing it to store the information data of target object's geographic coordinates or the like as the registered target point data TP.

At the route search processing step SA4 of Fig. 9, an appropriate or optimal route is searched for which extends from the guidance start point indicated by data SP to the final guidance point represented by data ED. Here, the "optimal route" refers to a recommended or best suited route that enables the vehicle to approach the target point at the minimum time period and/or with the minimum distance; alternatively, the optimal route may refer to a route allowing the driver to use wider roads or streets at increased priority. Still alternatively, on occasions where the driver wants to use a highway, the optimal route will be a route allowing the vehicle to arrive at the target point at the minimum time period and/or with the minimum distance while including the specified highway therein.

The guidance start point data SP allows either the same data as the present position data MP or the node data of a certain guidance object road near the present position data MP to be set therein. In the situations that the vehicle's present running position detected is out of the guidance route, another optimal route will be again searched automatically which route connects between a present out-of-route position and the last guidance point. It remains possible that when a temporal stop-at place is set as will be described later, the guidance route is modifiable so that it is replaced with a route that passes through such stop-at place.

At the guidance/display processing step SA5 in Fig. 9, the resulting guidance route as obtained by the route search processing at step SA4 is displayed on the screen of LCD 33 while letting the vehicle' s present position be centrally indicated thereon. The visual indication of such guidance route on LCD 33 is carried out to ensure that the same remains identifiable on an associative map display thereon. In addition to this, the navigation system is designed to allow guidance information to be audibly generated from speaker 13 in

the form of human voice speech or to be temporarily displayed on LCD 33 if required, thus facilitating reliable travelling of the vehicle along the guidance route as presently recommended. Additionally, image data for display of such guidance route is performed by use of either the road map information in the vicinity of a present position as stored in the data block 38c of information storage unit 37, or city map information near the present position.

Selective switching of the road map information and city map information may he performed depending upon the conditions that follow. For instance, the two kinds of data may be switched from one to the other depending upon either one of the distance from the present position to the guidance point (the target point, stop-at place or intersection), the velocity of vehicle, the size of displayable area, or operator's switch operations. Further, in the vicinity of the guidance point (the target point, stop-at place or intersection), an enlarged map near the guidance point is displayed on LCD 33. This may alternatively be modified so that a schematic guidance route image is displayed on LCD 33, which image indicatesin the alternative of such road maponly minimal amount of information as to the direction of the guidance route and the target point or stop-at place and a present position while the displaying of any geographic information is omitted therefrom.

After completion of the guidance/display processing at step SA5, the procedure of Fig. 9 goes to the nearby facility processing step SA6 and then to the other task processing step SA7. The nearby facility processing at step SA6 is to detect and designate any stop-at place (facility alike) other than the registered target point data TP. This process will be described in detail later.

The "other task processing" at step SA6 is for making a decision as to whether the vehicle's running position is along the guidance route as presently suggested based on computation. This step is also for determining if an instruction to alter the target point is entered through the operator's switch operations. After completion of step SA7, the procedure is then looped back to the present position processing step SA2; thereafter, the aforesaid steps SA3 through SA7 will be repeated. When the vehicle has arrived at the target point also, the route guidance/display processing step is terminated causing the procedure to go back at step SA2 again. In this way, a series of processing tasks at steps SA2 to SA7 will be repeatedly executed in a step-by-step manner.

8. Nearby Facility Processing

The nearby facility processing is to search for and select any stop-at facility the driver prefers to visit other than his or her final target place. The "stop-at" facility may be a gas station on occasions where the vehicle needs refueling on the way to approach the target place. Depending upon circumstances, the stop-at facility will alternatively be a restaurant, a bank, or others, rather than the gas station.

Fig. 10 shows a flowchart of one subroutine associated with the nearby facility processing step SA6 of Fig. 9. First, step SB1 determines whether a request on nearby facility is made by operator's operations of touch panel 34 of Fig. 1. If no such request is made, i. e., when the answer to step SB1 is NO, the subroutine skips intermediate steps to go directly to step SB8 whereat control returns to the main procedure routine of Fig. 9. On the other hand, if the answer to step SB1 is NO, the subroutine goes next to step SB2 following steps SB3 to SB8 in this order as will be described below.

At step SB2, a present position detection is performed, which may be similar to that of step SA2 in that the geographic coordinate position of the vehicle is determined based on the output information of respective sensors 21-24 in present position detector 20 of Fig. 1.

Then, control goes to step SB3 to determine if a nearby facility request is input by the operator. At this step SB3, the answer YES is issued even when no nearby facilities have been searched in the past. Accordingly, in the situation that the operator makes a request on a search for a nearby facility, the subroutine goes next to step SB4 for conducting such search If NO at step SB3, the subroutine skips step SB4 to enter step SB5 for determination of whether all facilities are requested for visual indication on LCD 33.

At step SB5 to which the subroutine enters when NO at step SB3 or after completion of the nearby facility search at step SB4, it is determined whether a display request is input by the operator with respect to all the facilities available. If YES to step SB5, all-facility display processing task is executed at step SB6. If NO at step SB5, the subroutine goes to step SB7 for execution of along-the-path facility display processing. After completion of steps SB6, SB7, the subroutine of Fig. 10 returns at step SB8 to the main control procedure shown in Fig. 9.

The "all-facility display" processing at step SB6 refers to a task for displaying all of the stop-at facilities being presently searched. The "along-the-path facility display" processing at step SB7 is for extracting from all the facilities only facilities located along the guidance route as searched at step SA4 and for displaying the same. The extracted facilities may be any objects insofar as they become a target, involving a point, location or facility as set by the operator.

The all-facility search processing is designed to conduct a search with respect to the entire region of associative map information corresponding to a target object as being externally input, irrespective of the route as presently suggested, and then display a resultant facilities searched. The way of displaying an output may vary depending upon situations: marks indicative of the facilities searched are superimposed and displayed at corresponding coordinate positions thereof on a map image displayed on LCD 33; or alternatively, there is

displayed a list of facility data consisting of a distance from a present position and/or a direction relative to the present position for each facility.

It should be noted that in the first display method for superimposing the marks indicative of facilities onto the map image, it remains possible that such facility marks continue to be displayed on the map even when it is forced to move by scroll in accordance with cursor movement or with movement of the vehicle's present position.

9. Nearby Facility Search Processing

Fig. 11 shows a subroutine associated with the nearby facility search processing at step SB4 of Fig. 10. First, at step SC1, a list for genre selection is displayed. The "list for genre selection" refers to the one that represents the kind of genre to which each facility of the facility data file F16 belongs. Accordingly, based on this genre list, any suitable genre that meets the stop-at purpose may be selected by the operator.

Fig. 18 depicts an exemplary genre list to be displayed on the screen of LCD 33. As shown, the names/titles of respective genres (here, a convenience store, family restaurant, gas station, etc.) are indicated in a corresponding column 116 on a screen 100.

Turning back to Fig. 11, after completion of genre list displaying task at step SC1, the subroutine goes next to step SC2 for determining if an interrupt request is made. If such request is present, that is, when the answer to step SC2 is YES, an interrupt processing is executed at step SC7. The "interrupt processing" may be entry of termination of the nearby facility search processing, for example. The interrupt processing is also necessitated on the occasions where an expected operation of selecting the genre from the list displayed at step SC1 is kept inactive for a predetermined time duration.

When no interrupt request is found at step SC2, i.e., if NO at step SC2, the subroutine goes to step SC3 to determine if the operator's genre selecting operation is present. If NO, the subroutine is looped back to step SC2 for repeated execution of similar interrupt-request determination again. If YES at step SC3, the subroutine goes next to step SC4.

When a genre is designated through the decision at step SC3, more than one facility which belongs to such genre and falls within a predefined range of 10-km radius with a present position of the vehicle as the center is then searched from among those of the facility data file F16 at step SC4. In other words, only the facility(ies) belonging to the designated genre may be exclusively searched from respective facilities as stored in data file F16. Simultaneously, the geographic linear distance relative to the vehicle's present position is calculated by use of the north latitude coordinate SNO and east longitude coordinate SEO of each of the facilities searched.

Then, an associated number of each facility having its computed linear distance within the 10-km rangenamely, the identification number of each facility contained in the facility data file F16is stored in the first RAM 5 as a search facility number GBn. Next, at step SC5, a decision is made as to whether the presently searched facilities are subject to a further limited search under more strict kind conditions thereby to extract only the facilities as located along the route. In other words, a decision is made as to whether the operator instructed to extract from the resulting searched facilities the specific "along-the-path" facilities that are located along the guidance route.

When such "narrowing" of facilities is designated, i.e., if YES at step SC5, the subroutine goes to step SC6 for execution of extraction of such along-the-path facilities only. When the narrowing search for along-the-path facilities is not designated, i.e., if NO at step SC5, the subroutine is forced at step SC8 to return to the main procedure of Fig. 9. This is also done upon completion of the along-the-path facility extraction at step SC6. 10. Extracting Along-The-Path Facilities

Fig. 12 shows a subroutine of the along-the-path facility extraction processing at step SC6 of Fig. 11. This subroutine of Fig. 12 begins with step SD1 which calculates a geographic minimum linear distance from a facility to the guidance route based on the geographic coordinate data of each facility as searched at step SC4. An associated subroutine with this minimum linear distance calculation is separately shown in Fig. 13. The "guidance route" refers here to the guidance data MW as obtained by the route search processing in the main procedure shown in Fig. 9. Fig. 6 is a diagram for explanation of the positional relation of any detected facility and the guidance route. The route from the guidance start point toward the target point is the one as obtained by the route search processing at step SA4 of Fig. 9.

At step SD2 of Fig. 12, only specific facilities are extracted each of which has the resultant minimum linear distance as obtained at step SD1 which falls within a predetermined range of about 150 m. Each facility extracted at step SD2 is then subject at step SD3 to a subsequent determination as to on which sidei.e., on the right side or the left the facility is located with respect to the vehicle's running direction along the guidance route.

Fig. 7 is a presentation of a model for use in explaining how the processing at step SD3 is carried out. Coordinates (X1, Y1) represent a node near a certain facility with its own coordinates (Xb, Yb), and corresponds to a node S1 shown in Fig. 6. Reference coordinates (X0, Y0) may correspond either to a node S2 of Fig. 6 or to a present position of the vehicle. Consequently, a reference vector a = (ax, ay) connecting between the coordinates (X1, Y1) and reference coordinates (X0, Y0) represents a branch 60 shown in Fig. 6. Here, the reference vector a satisfies: $a = (ax, ay) = (X1\text{-}X0, Y1\text{-}Y0)$. The coordinates (X1, Y1) and reference coordinates (X0, Y0) are selected so that these are identical to those of a specific node near-

est to the facility with the target coordinates (Xb, Yb).

For the reference vector a, an orthotomic vector c is defined which is rotated by 90 degrees in the counterclockwise direction to satisfy: c = (-ax, ay) . Also defining a target vector b that connects together the reference coordinates (X0, Y0) and facility's target coordinates (Xb, Yb), the target vector b and orthotomic vector c internally defines a vector space at angle therebetween. Note that the target vector b may be defined as: b = (Xb-X0, Yb-Y0) . The inner product of the reference vector a and target vector b is defined by:

$$cb = |b| \times |c| \times \cos\theta.$$

When the value of such inner product of vectors c, b is positive in polarity, it is determined that the facility of interest is on the left side of the running direction along the guidance route. If by contrast the inner product is negative in polarity, the facility is determined to be on the right side of the running direction. In this way, at step SD3, the relative right/left position of any one of the extracted facilities with respect to the guidance route is exactly determined depending upon whether the vector inner product is positive or negative in polarity. This enables exact right/left direction of the target object to be easily achieved merely based on the plus/minus judgement of the calculation result of inner product. The right/left data RL thus judged is then stored in the first RAM 5. Additionally, assuming that there are two nearest nodes close in position to the facility under test, the reference coordinate point (X0, Y0) of Fig. 7 is selected so that it is one of the two nodes which is near the start pointe.g., the node S2 in the case of the illustrative example in Fig. 6. Conversely, for the coordinate point (X1, Y1), the other of the two nodes which is near the target point rather than the start point is selectede.g., the node S1 in Fig. 6.

It should be noted that the orthotomic vector c may alternatively be the one rotated by 90 degrees in the clockwise direction with respect to the reference vector a; or still alternatively, it may be the outer product of reference vector a and target vector b, as defined by $|b| \times |c| \times \sin\theta$. Once the right/left position of each extracted facility is detected with respect to the guidance route, the facility-to-target distance Zn indicative of the distance from each extracted facility to the target point is calculated at step SD4 of Fig. 12. The distance Zn is the one being measured along the guidance route. This may refer to the along-the-path distance from point P1 toward target point shown in Fig. 6. Accordingly, in the illustrative example of Fig. 6, the linear distance from point P1 to node S1 added with respective linear distances of branches 64, 65, 66 results in the facility-to-target distance Zn. Note that the reference vector a may be set to any one of the vehicle's running direction, the vehicle-to-target direction, the north, the south, the east, the west, and a direction as set by the operator. Note also that the facility-to-target distance Zn may alternatively be added with the minimum linear distance (as obtained at step SD1 of Fig. 12).

Based on the resulting facility-to-target distance Zn, the extracted facility data are sorted at step SD5 in Fig. 12. By way of example, they are sorted into an decremental sequence that the greatest one in facility-to-target distance Zn comes first. Thereafter, the subroutine of Fig. 12 returns at step SD6 to that of Fig. 11.

11. Calculating Minimum Linear Distance

Fig. 13 shows a subroutine for the minimum linear-distance calculation step SD1 of Fig. 12 which calculates the minimum linear distance between one searched facility and the guidance route. Fig. 6 is a diagram for explanation of the relative geographic positional relation between a facility located along the guidance route and this route. Fig. 8 is a diagram for explanation of calculation of the minimum linear distance. As described previously, the route of Fig. 6 from the guidance start point to the target point is the route as obtained by route search processing at step SA4 of Fig. 9.

Nodes S1, S2 shown in Fig. 8 correspond to those S1, S2 of Fig. 6. The geographic minimum linear distance between the coordinates P2 of one facility searched by the nearby facility search processing at step SB4 and the guidance route is calculated in a way that follows. First, at step SH1 of Fig. 13, two nearest nodes S1, S2 that are close in position to the subject facility are selected in the guidance route. Detection of such two specific nodes from among several nodes along the guidance route may be performed as follows: calculate a linear distance of each node to the coordinates P2; find among the resulting distance values two specific values one of which is the minimum and the other of which is the second minimum; and, specify two nodes related to the first and second minimum values as the "nearest nodes" to the guidance route.

Then, the routine of Fig. 13 goes to step SH2 for calculating the coordinates of Intermediate or "midway" points J1, J2,... which equally m-divides a line connecting the two nodes S1, S2, based on the geographic coordinates of each node S1, S2. At step SH3, the m-division midway points J1, J2,... are subject to distance calculation obtaining the geographic distance of each point Ji (i = 1, 2,...) to the coordinates P2 of the facility of interest, which distance is defined by the length of a corresponding line Ri connecting points Ji and P2.

Next, at step SH4, the distance value of line R1 is set to the minimum value Rmin as its initial value while letting a conditional variable NS be at "2" as the initial value thereof. At step SH5, the geographic distance of the NS-th line R(NS) designated by the conditional variable NS is compared with the minimum value Rmin to determine which is greater in value. When the value of line R(NS) is greater than the minimum value Rmin, the answer to step SH5 is YES. If this is the case, the geographic distance value of line R(NS) is set to minimum value Rmin at step SH6. After execution of this value

replacement, the conditional variable NS is incremented by one (1) at step SH7.

On the other hand, when the minimum value Rmin is less than the distance value of line R(NS), that Is, if NO at step SH5, the subroutine of Fig. 13 skips step SH6 and goes directly to step SH7. Subsequently, at step SH8, a decision is made as to whether the conditional variable NS is greater than the number of m-division midway points J on the node line S1-S2 of Fig. 8. If NO at step SH8, control is looped back to step SH5 repeating steps SH5 to SH8. If YES at step SH8, the routine returns at step SH9 to that of Fig. 12.

With the above control procedure, the minimum value Rmin is finally set at a specific value that is substantially equal to the minimum linear distance from the coordinates P2 of the facility of interest toward the node connection line S1-S2. This minimum value Rmin is thus used as the best possible facility-to-route distance Rmin between the facility and guidance route. This minimum value Rmin may be identical to a foot of a perpendicular from the target facility onto the node connection line S1-S2, which in turn represents a distance to the target facility. Additionally, the minimum linear distance calculation processing may alternatively be carried out in such a way that the distance from node is obtained by mere calculation of a distance from node S1, S2 to the target facility.

12. Along-The-Path Facility Display Processing

Fig. 14 shows a subroutine for the along-the-path facility display processing at step SB7 in Fig. 10. This routine begins with step SE1 which calculates a remaining run distance OP from the vehicle's present position to the target point. In this case, length data of the road data pursuant to the guidance route data MW is accumulated to provide an accumulated value, which is then added with a distance from the vehicle to a next node.

The "remaining run distance" OP refers to the actual distance in case where the vehicle has moved toward the target point along the guidance route as presently searched. Control goes next to step SE2 causing the facility-to-target distance Zn obtained at step SD4 of Fig. 12 and the remaining run distance OP to be subject to:

$$Wn = OP - Zn.$$

The resulting vehicle-to-facility distance Wn defines a relative along-the-path distance between a present position of the vehicle and each extracted facility along the guidance route. If the vehicle-to-facility distance Wn is negative in polarity, it is determined that the facility is present at a "past" position which is somewhere back toward the start point along the guidance route. After completion of the vehicle-to-facility distance Wn calculation, control goes to step SE3 to determine if a map display request is made. This step makes a decision as to whether direct display on map is selected as a display method of each extracted facility (along-the-path facility).

When the map display is requested, that is, if YES at step SE3, control goes to step SE4 to temporarily designate a certain facility which is positive in polarity of the value of vehicle-to-facility distance Wn and yet remains minimum in value thereof, allowing such temporary designated facility to be displayed on LCD 33 of Fig. 1 along with the vehicle's present position at an appropriate contraction scale. Here, on the map image displayed, any extracted facility is visually indicated by use of a corresponding mark that is predefined exclusively thereto. This mark may be designated using one of the mark number SPN as stored in the facility data file F16 shown in Fig. 2.

After completion of map display at step SE4, control goes next to step SE5 to determine if any interrupt processing is requested. If YES at step SE5 (upon request of an interrupt), any kind of processing under request is executed at step SE6; then, at step SE7, the along-the -path facility display processing is terminated and returns to the subroutine of Fig. 10. The interrupt processing, here, may include a case where the operator's operations for selection remain inactive for a predefined time duration.

When such interrupt request is absent, that is, if NO at step SE5, control goes to step SE8 to determine if a stop-at facility is decided by the operator who operates the tough panel 34 of Fig. 1. If YES at step SE8, control skips to step SE12 which sets the decided facility as a beep point in such a way that the information as to the geographic coordinates of such facility is stored in the first RAM 5 as beep point data BP. The data BP is for later use in informing, by issuing audible information such as voice sound, the user of the fact that the vehicle is near the intended facility.

On the other hand, if NO at step SE8, control goes to step SE9 to determine if cursor movement operations are wade. If YES at step SE9, control proceeds to step SE10 which causes a next facility to be displayed on the screen in such a way that when a next facility is selected, a corresponding facility is designated which is the second greatest in value of vehicle-to-facility distance Wn. At this step, it may happen that the operator's cursor operation indicates a "backward" instruction; if this is the case, certain facilities are sequentially designated from among those located along the "past" route the vehicle has already passed, in an order that one comes first which is smaller than the others in absolute value of vehicle-to-facility distance Wn.

Then, at step SE11, more than one facility designated at step SE10 and the vehicle's present position is displayed on the screen together with an associative map image thereon. In this case, each facility is displayed on the right or left side of guidance route 104 pursuant to the right/left data RL. The display position of each facility is different from the map display in that any facilities are indicated in the same column (same in kind and in level) regardless of their actual distances from

the guidance route while permitting association of corresponding audible output signals informing the individual facility name/title and its relative positioni.e., "right" or "left" which may be voice guidance. It has been described that the guidance route 104 may be any one of the vehicle's running direction, the operator's set direction and others. During the facility display at step SE11, associative characteristic marks are also visually indicated enabling easy identification of such designated facilities, which marks are designated by the mark numbers SPN.

When the answer to step SE9 is NO (no cursor operations), or after completion of displaying new facilities at step SE11, control is looped back to step SE5 for reexecution of this step and its following steps. When NO at step SE3 (map display selection is inactive), control goes to another subroutine shown in Fig. 15.

The subroutine of Fig. 15 is a program module for displaying a list of along-the-path facilities as presently extracted. This program begins with step SF1 which displays a list of respective facilities along with their vehicle-to-facility distance Wn as obtained at step SE2 of Fig. 14. See Fig. 17, which depicts one exemplary facility list being visually indicated at step SF1. Line 104 of Fig. 17 denotes the guidance route, whereas symbol 106 indicates a present position of the vehicle.

A mark 103 represents one extracted facility accompanying with a numeric indication 102 informing the vehicle-to-facility distance Wn thereof. Like numeric indications are also given to other extracted facilities 107, 108,.... A minus (-) symbol is used for such distance indications 102 to show that a corresponding facility associated therewith is a "past" facility located in the "backward" route the vehicle has already passed along the guidance route 104. In addition, the relative display positions of facilities 103, 107, 108,... with respect to the guidance route line 104 are specifically arranged so as to tell whether a facility is on the right side or the left side of line 104; for example, the facility mark 103 being displayed on the right side of line 104 informs the fact that this facility is on the right-hand side of the guidance route, whereas the facility mark 107 displayed on the left side of line 104 tells that it is on the left-hand side thereof. While not illustrated, the facility-to-route distance Rmin may also be displayed together with the vehicle-to-facility distance Wn. It will be recommendable depending upon situations that the total distance Wn + Rmin be also displayed with respect to each facility. The facility names/titles and associated distances may be output in the form of voice speech as electronically synthesized or playback signals.

After display of facility list at step SF1, control goes to step SF2 to determine if an interrupt is requested. If YES at step SF2, a corresponding interrupt processing is made at step SF3 causing at step SF4 control to return. The interrupt processing may be required, for example, in case where the operator's operations for selection remain inactive for a predefined time duration.

If NO at step SF2 (no interrupt request), control goes next to step SF5 which determines if stop-at facility selection is made by the operator who operates tough panel 34. If YES at step SF5 (selection is active), the selected facility is set at step SF8 as a beep point. Namely, information as to the geographic coordinates of such facility is stored as beep point data BP in the first RAM 5 of Fig. 1.

Then, at step SF9, both the facility selected at step SF5 and the vehicle's present position are displayed on the screen of LCD 33 along with its associated map image thereon. During the map display accompanying with such facility(ies) at step SF9, a characteristic mark is used to render the selected facility visually identifiable, which mark is designated using the mark number data SPN.

Alternatively, if NO at step SF5 (facility selection is inactive), control goes to step SF6 to determine if any cursor activation is made. If YES, the list being displayed on the screen is scrolled at step SF7 with movement of cursor operated; for instance, where display of frontal or "future encounterable" facility(ies) is requested due to the cursor activation operations, more than one additional facility greater in vehicle-to-facility distance Wn is displayed. Referring to the example of Fig. 17, the display image is scrolled down in such a way that data regarding the last facility 108 is forced to disappear from the screen 100 causing data of a new facility to appear instead at the uppermost level of the screen. Conversely, the operator's cursor operations indicates the "backward" instruction, the uppermost facility 103 disappears from screen 100 allowing one "past" along-the-path facility that the vehicle has already passed along the guidance route to appear at the lowermost level of screen 100.

Turning back to the routine of Fig. 15, if NO at step SF6 (no cursor movement), or after completion of scrolling of facility list display at step SF7, control is looped back to step SF2 for reexecution of this step and its following steps. When YES at step SF5, control goes next to step SF8 for setting a selected facility as a beep point, and then to step SF9 which may be similar to step SE11 of Fig. 14. Finally, control is forced at step SF10 to return to the control routine of Fig. 10.

13. All-Facility Display Processing

Fig. 16 shows a subroutine program module associated with the all-facility display processing at step SB6 of Fig. 10. The routine of Fig. 16 begins with step SG1 which calculates the linear distance of the vehicle's present position to a respective one of searched facilitiesnamely, those searched for at step SC4 of Fig. 11 and fall within the 10-km rangeby use of the geographic coordinate data of each facility. The "linear distance" here have no connection with the guidance route being presently searched. Then, at step SG2, the direction of each facility when looking at from the vehicle's present position is obtained based on the coordinate data thereof.

Control then enters step SG3 which attempts to sort a set of facility data items, based on the resulting linear distance data as obtained at step SG1, into a regular incremental sequence by using the distance values as sort keys. Control goes next to step SG4, which displays a corresponding list on the screen of LCD 33 while allowing the directions and distances to be indicated on a one-to-one correspondence basis. Each direction is displayed by use of either an arrow or a character set, wherein the former may assume the upper side of screen as the vehicle's running direction, whereas the latter may use a word such as "Northwest."

After the list display at step SG4, control goes to step SG5 to determine if an interrupt is requested. If YES, a corresponding interrupt processing is ride at step SG6. The list-display is terminated at step SG7 causing control to return. As in the preceding cases, the interrupt processing way be required on occasions where the operator's operations for selection remain inactive for a predefined time duration. When NO at step SG5 (absence of interrupt request), control goes next to step SG8 to make a decision as to whether stop-at facility selection is made by the user. If YES at step SG8, a selected facility is displayed at step SG11 on the screen of LCD 33 along with the vehicle's present position.

During the map display accompanying with the facility(ies), it is required that the facility and vehicle's present position be visually indicated with an appropriate contraction scale permitting simultaneous display of the two on the screen. In such facility display at step SG11 a characteristic mark is employed to render the selected facility visually identifiable, which mark is designated using the mark number data SPN. In this case, the name/title identification SN may also be displayed. Next, at step SG12, the selected facility is set as a beep point. In other words, information concerning the geographic coordinates of once-determined facility is stored as beep point data BP in the first RAM 5. When required depending upon occasions, control goes to step SG13 which conducts a search again to find out another possible guidance route containing the presently selected facility.

When NO at the preceding step SG8 (no facility selected), control goes then to step SG9 to determine if cursor movement is made. If YES at step SG9, the list being presently displayed on the screen is controlled at step SG10 to scroll upward or downward with cursor's movement. After completion of such scrolling of list display image at step SG10. or when NO at step SG9, control is looped back to step SG5 as shown in Fig. 16 for reexecution of related steps in substantially the same way as described previously.

After a specific facility is selected completing necessary route correction processing pursuant to the updated facility selection through steps SG12, SG13, control is caused at step SG14 to return to the procedure of Fig. 10. In this way, with the all-facility display processing subroutine shown in Fig. 16, facility search is conducted regardless of the guidance route in such a way as to find out more than one facility that falls within the "radius 10-km" range with the vehicle's present position as the center thereof. Note that the reference point for use in conducting such "all-direction facility" search will not exclusively be limited to the vehicle's present position; for example, the all-direction facility search is carried out with a certain "past" position of the vehicle (such as the vehicle's start point) as a reference, thereby permitting visual indication of the distance to each facility from the vehicle's position on the way of travel along the guidance route.

More specifically, with the present invention, the reference point adaptable for use in extracting along-the-path facilities or in conducting all-direction facility search should not be exclusively limited to the vehicle's present position. The search reference point may alternatively be either one of the following: a target point set before the vehicle begins running; a pass-through point or transit node on the optimum route toward the target point, such as an intersection, a characteristic building, etc.; a given point in a map image on the screen of LCD 33 as designated by the operator; or a point on the optimum route presently displayed on LCD 33, involving an intersection, a building, etc. Also, the search conditions as employed in the nearby facility search processing made at step SC4 of Fig. 11 should not be limited exclusively to the surrounding 10-km range: such range may be broadened or narrowed, or may be maximized to cover the entire area of an associated map as necessary. The extraction conditions as employed at step SD2 of Fig. 12 is not limited to 120 m only: it may be extended or shortened if needed.

The stop-at facility selection processing in the illustrative embodiment may to modified such that more detailed information is additionally displayed for respective facilities; or alternatively, it is modified to permit additive execution of a narrowing search for more exact facilities based on such detailed information. By way of example, assuming that the designated genre is a restaurant, there will be displayed specific information as to practical menu items, such as Japanese, western, Chinese, or the like, thereby allowing the search to be further narrowed in field as pursuant to the kind of food in such menu items.

It should be noted in step SC4 of Fig. 11 that exact indication of the coordinates of each facility may be deleted if appropriate; also, where the road has a median strip, and if it is a conditional one with the "no right turn" prohibit sign at its associated intersection, right -side neighboring facilities may also be withdrawn from consideration. In this case, a road condition extractor is provided for extracting the environment of each road related to the presently searched guidance route. Based on the road conditions as read by the road condition extractor, a facility canceler acts to make a decision as to whether a presently extracted facility is to be withdrawn as far as the search is concerned.

The road condition extractor attempts to read from the road data file F4 of Fig. 2 road attribute data, cau-

tion/warning data, etc. The resultant read data may be used to determine the road environment of the guidance route nearest to the extracted facility, thereby enabling the facility canceler to determine if it is difficult for the vehicle to stop at or drop in such facility. This may inhibit occurrence of any improper selection of such facility that is very difficult for the vehicle to stop at or drop in.

It should also be noted that external information such as the VICS, ATIS or the like may be fetched to be used as the stop-at facility extraction conditions. For instance, in the case where one parking area around the target point is extracted as the stop-at facility, any proper facility is extracted using the external information including VICS or ATIS, and also by taking into account the full/empty state of each parking area and/or the traffic congestion on roads around that facility. This may serve to further reduce the risk of selecting unsuitable or "erroneous" facilities. Additionally, a unique processing is provided to force the nearby facility search processing start instruction to be disenabled while the vehicle is running.

As can be seen from the foregoing, with the navigation system embodying the invention, whenever the driver happens to want to stop at a certain place on the way to the initially intended target place, some along-the-path facilities are promptly displayed along with their respective distances as measured from the vehicle's present position. This may widen the range of selection of such stop-at required facility, thereby enabling optimized facility selection.

For example, while the vehicle is on the way to the target point from a present position thereof, even if no facilities satisfying the purpose are found, it will possibly happen that one satisfactory facility exists at a "past" location backward along the guidance route, at which the vehicle can arrive if it turns back halfway. Even in this case, the navigation apparatus embodying the instant invention can provide easy selection of stop-at facility by permitting visual indication of several past facilities located along the guidance route.

Another advantage of the embodiment is that in case where a plurality of stop-at facilities extracted, the time required for facility selection can be shortened by intensifying the narrowing search conditions as described previously thereby to display only limited stop-at facilities that meet the user's demands more significantly.

The facility search processing may be modified so as to conduct a search for facilities based on the route with respect to the entire area of an associated map information. In this case, the user who is driving the vehicle along the route can stop at his or her preferred facility without having to significantly get out of the route. In addition, selectively displaying certain facilities within a desired range from a reference point (a present position, target point, cursor position, etc.) may enable the user to obtain his or her requested information quickly and distinctly.

A further advantage of the embodiment is that the position or location of any desired facility relative to the route can be specifically indicated by providing schematic diagrams indicative of the positional relation based on the route information and facility information. Furthermore, since the navigation system is designed to make a decision as to on which sidei.e., right side or left sideof the forward direction of route the presently searched facility is present thereby allowing a corresponding mark to he displayed on the judged side in the schematic diagram, it becomes possible to more particularly indicate the positional correlation of the route versus facilities.

In the schematic diagram preparation processing, the schematic diagram is arranged to encompass a specific range from the start point up to the target point; alternatively, in case where the target point and additive transit node(s) are set with a present position as a reference, the schematic diagram may be modified so that it indicates the target point and transit node(s) from the present position, or it employs a rough route configuration including one segment extending from the start point to one transit node and another segment from the transit node up to the target point. Additionally, indicating such transit node(s) in the schematic diagram may enable easy selection of facility on occasions where the driver wants to stop at one of such facilities before the vehicle pass through it.

In addition with, it is an object of the present invention to provide a navigator apparatus capable of searching for nearby facilities around a present position of a vehicle while eliminating any increase in data capacity yet enhancing visibility by use of information of landmarks as used for guidance display.

To attain the foregoing object the present embodiment is specifically arranged as follows:

(1) In a navigator providing route guidance with movement of the vehicle, the nearest or nearby facility is searched and guided without having to increase the data capacity of associated storage devices.

(2) In a vehicle navigator, this comprises an information storage device for storing therein map information for use in drawing map information, a present position detector for detecting a present position, an input device for allowing entry of search conditions, a searcher for accessing the information storage device to search for one or several facilities near the present position based on the conditions as input by the input device, a display device for displaying a search result obtained from the searcher, and a selector for selecting at least facility from among those being displayed on the display device, the improvement wherein the map information stored in the information storage device may include landmark information as to facilities, wherein the searcher conducts a search based on the landmark information, and wherein the display device visually indicates the map information with a

certain facility selected by the selector as a center.

Now consider one exemplary road network shown in Fig. 22 wherein several roads designated by numbers (1) to (14) associate with road junctions or intersections denoted by numbers I to VII. As shown in Fig. 24, the road No. (1) may be defined such that it has: a next road No. (11) with the same start point, a next road No. (4) with the same termination or end point, a start point corresponding to intersection No. II, an end point corresponding to intersection No. I, a node array pointer A000, and road length of 1,000 m. In this way, the roads are sequentially defined in number in the table format of Fig. 24, thereby defining the road network

Figs. 23a-23d diagrammatically represent data as to intersections. As shown in Fig. 23a, each intersection is added with the intersection number, intersection coordinates (the north latitude and the east longitude), connection road information, landmark (eye-catch mark pattern) data address, size, etc. As shown in Fig. 23b, the landmark data comes with landmark coordinates (the north latitude and the east longitude), a mark pattern number, and a facing road number (two road numbers are stored if the landmark is at the corner of an intersection), which are assigned to every landmark As shown in Fig. 23c, the mark pattern number is determined for example as follows: "0" is for bank mark drawing data, "1" for bank mark drawing data, "2" for bank mark drawing data, "3" for gas-station mark drawing data, "4" for gas-station mark drawing data, and so forth.

Additionally, each landmark (eye-catch mark) data is added with an offset value, mark pattern number, and facing road number. Here, all the landmark data items and intersection data items are stored on a one-to-one correspondence bases. The landmark data may accompany with corresponding north-longitude/east-latitude coordinates; or alternatively, as shown in Fig. 23d, it may come with an offset value with the intersection coordinates as a reference (vector value with its associated intersection coordinates as the origin). The latter will be more preferable than the former because of the fact that landmark drawing control becomes more simpler when landmarks are to be drawn into an enlarged intersection diagram which assumes that the vehicle's running direction is upward while the entrance direction thereto is deemed upward also.

Figs. 25a through 26d are diagrams showing several structures of the road data in accordance with the present invention. Fig. 25a shows guidance road data, which may include for every roade.g., with respect to each of the road numbers (1) to (14) as shown in Figs. 22 and 24a chain of data items such as a length, road attribute data (see Fig. 26a), shape data address, size, guidance data address, and size; the shape data has, for example, the north- longitude/east-latitude data as shown in Fig. 25b. As shown in Fig. 25c, the guidance data contains therein an intersection identification (i.e., name/title), presence/absence indication of a signal, landmark data, caution or warning data, road ID (name/title), road ID audio data address, its size, destination data address and its size.

It is apparent from viewing Fig. 25d that the destination data contains a destination road number, destination ID, destination ID audio data address, its size, destination direction data, run guidance or navigation data, and others. As shown in Fig. 25e, the destination direction data has either one of the following data items: "-1" indicative of invalid, "0" for unnecessary, "1" for go-straight, "2" for right direction, "3" for oblique right direction, "4" for turn back to the right, "5" for back to the left, "6" for oblique left direction, and "7" for turn back to the left.

As shown in Fig. 26a, the road attribute data typically consists of a first part regarding the elevated-track/subway road data, and a second part concerning the lane number, wherein the former includes indication of an elevated track, "beside the elevated-track," subway road and "beside the subway road," whereas the latter contains indication of "equal to or more than three lanes," two lanes, single lame and absence of center line.

As shown in Fig. 26b, the road ID data consists of a road kind or type data block and a type number data block, wherein the former is divided into a plurality of data items including a highway, city speed-way (expressway), toll road (turnpike), and public road, which is subdivided into categories of national road, prefectural road and others. Regarding the highway, it is with "1" for a trunk line, or " 2" for an access line (branch road) to be coupled to a next road. The same goes with the remaining roads.

As shown in Fig. 26c, the caution data includes a plurality of items that follow: a railroad crossing, tunnel entrance, tunnel exit, lane-width decrease point, and "no cautions associated." As shown in Fig. 26d, the navigation guidance data contains several items including "from the right," "from the left," "from the center," and "none."

Fig. 27 is a flowchart showing the main control procedure for navigation operations of a navigation system in accordance with a further embodiment of the present invention, as will be described in detail below.

Upon activation of the navigator, the control procedure begins with step S11 which attempts to detect a present position of the vehicle by use of an associated present position detector device. Then, at step S12, a target place input processing is carried out to permit entry of any desired target place. Entry of such target place may be done through a menu screen as presently displayed on an input device 41, for example. This may alternatively be accomplished based on telephone numbers.

Control goes to step S13 to search for a route leading to the target place based on a vehicle's present position being detected by the present position detection processing and the target place which has been input by the target-place input processing. More specifically,

this task includes substeps of: calculating one specific node nearest to the coordinates of the input target place; and then, conducting a search for a route leading to the resulting node calculated from the present position, which search is based on several search conditions (for example, the minimum distance, minimum time, presence/absence of toll-road priority, ease of running, etc.). Control goes next to step S14 which executes route guidance pursuant to a resultant path or route as searched by the route search processing, which guidance is based on the detection result of the present position detector (including GPS, gyro sensor, distance sensor, etc.) and also by taking into account of the actual movement of the vehicle's present position.

A guidance display and point search display scheme of the embodiment system will now be described with reference to Figs. 19 to 21. Fig. 19 is part of an associated map that shows one exemplary route in the route search as executed by the navigator embodying the invention. Figs. 20a to 20d show some exemplary guidance indication and point-search display images which may take place while the vehicle is running along the route. Fig. 21 is a flowchart of a guidance display/point-search display processing to be performed by the navigator.

Imagine in the map of Fig. 19 that the vehicle now leaves from the Minami Grade School (A) with this place as a start point to travel for its target placee.g., Kannon-Do temple and shell-heap historic site (C) by way of a certain pass-through or transit place, here, Komuro Grade School (B).

In this situation, the start point (A), transit node (B) and target point (C) are set in the navigator, letting the vehicle run to the target. When the vehicle arrives at an intersection (1) in the map of Fig. 19, the navigator provides voice guidance suggesting it to turn to the right while displaying a "turn-to-the-right" intersection diagram; accordingly, the vehicle turns to the right and continues running. Thereafter, it arrives at another intersection (2); then, the navigator provides voice guidance suggesting it to turn to the left while displaying a "turn-to-the-left" intersection diagram; the vehicle turns to the right accordingly and continues running. Thereafter, the vehicle arrives at a still another intersection (3). At this time, the navigator provides voice guidance suggesting it to turn to the right while displaying a "turn-to-the-right" intersection diagram; accordingly, the vehicle turns to the right and continues running. As shown in Fig. 20a, this intersection (3) accompanies with a guidance indication of a gas station 2. Here, the numeral 1 designates a corresponding picture image of the intersection, 3 denotes the intersection ID ("A" town, in this example), 7 indicates the vehicle's present position, and 8 is an arrow mark showing the "turn-to-the-right" movement.

Turning back to Fig. 19, after the vehicle turns to the right at intersection (3) to continue running along the road, it arrives at a left-hand transit node B in the map. Assume that this point is for picking up a fellow passenger who is expected to ride in the vehicle.

Imagine that the driver becomes aware of the shortage of gasoline which necessitates him or her to search for a gas station. If this is the case, the driver operates the navigator causing it to display a search menu as shown in Fig. 20b. Upon selection of an item labeled " around- information search," the genre list of Fig. 20c is soon displayed. The driver selects a menu item "gas station" and sets a "10 -km around" condition to finally select one appropriate gas station that meets the driver's demands.

Then, a list of several nearby gas stations are diagrammatically indicated using their corresponding landmarks as shown in Fig. 20d. This diagrammatic image contains therein official marks of gas stations along with respective distances from the present position. Upon selection of one preferable gas station, the navigator begins conducting a search with this gas station as a target point; after the search is done, the result is displayed on a display screen (not shown).

After the route search enabled the vehicle to refuel at the gas station, the navigator again attempts to search for the preceding target place (C) allowing the vehicle to travel through intersections (4), (5) to thereby finally reach the target place (C).

Note here that the gas stations represented by the landmarks may also be used as part of point-search information together with guidance display information for route guidance.

A description will be given of the guidance display/point-search scheme as employed in the navigator embodying the invention in connection with Figs. 1, 19 and 21.

As shown in Fig. 21, the control procedure includes the steps of:

(1) setting as the search area a region of coverage of 10 km with a map center being presently displayed as a search area center (step S1);
(2) reading map information within the search area from a map information file of an information storage device 50 (step S2):
(3) causing a CPU 21 to calculate or compute a distance between an eye-catch marker information (landmark data) and the coordinates of the map center (step S3);
(4) storing resultant marker signals, distance values and marker position calculated by the CPU in a distance- decremental sequence that the shortest distance comes first and the longest one follows last (step S4);
(5) displaying pairs of landmarks and distance values corresponding to respective marker numbers in a sequential order, while permitting use of the exemplary diagrammatic image shown in Fig. 20d if they are related to gas-station information (step S5); and
(6) determining whether user's operation for selection of a landmark from those presently displayed

(step S6); if YES, displaying the map information with such selected landmark as a center (step S7).

A register device and its associated storage device for storing therein registered information are arranged to enable registration of the selected facility as a particular point such as a transit node or target place, whereby it becomes possible to recalculate the route to a corresponding facility, which will provide maximized convenience.

While the embodiment is arranged to include the landmark data in the intersection data, it may be modified so that the landmark data is stored in the road data, or alternatively, used as eye-catch mark data containing therein position coordinates, mark information and others.

In the navigation apparatus arranged as described above, the facility search data for use in searching for nearby facilities can remain cooperative and common with the map information for displaying map information reducing the data capacity as a whole. Further, due to the possibility of displaying or visually indicating landmarks indicative of corresponding facilities, when compared with the genre-designation search scheme, it becomes possible for users to readily recognize the facilities being presently displayed enabling execution of optimal facility search.

While the foregoing description is made under an assumption that the embodiment is drawn to the point-search for a gas station, the present invention should not be limited exclusively thereto. The point-search may be extended to a search for a parking area which is hard to find out in the city; in this case, drivers can easily find out their preferred parking area during a drive without having to iteratively access other information sources. Moreover, it is also possible during a drive to obtain some related information as to the nearest convenience store, family restaurant, bank, post office, station, hotel or the like. As can be seen from the foregoing, utilizing the route guidance display information also as part of point-search information may enable drivers to obtain any information of interest relating to nearby facilities while they are driving their mobile vehicles, permitting more comfortable driving.

Although the preferred embodiments of the present invention have been illustrated in detail, it should be apparent that modifications and adaptations to those embodiments may occur to one skilled in the art without departing from the scope of the invention. For instance, the data storage devices for storage of various kinds of data shown in Fig. 4 may be any data writable devices, including floppy diskette drive modules. The navigator may be arranged to come with a voice input device having an analog-to-digital converter, wherein respective operations are ride under voice instructions as input through the audio input device.

Further, the navigator system of the present invention may not necessarily include the entire subroutine program modules shown in Fig. 9 in the program block 38b of the information storage unit 37 of Fig. 1. For example, while the present position processing, target point set processing, route search processing and guidance/display processing made at steps SA2 through SA5 are executed using program block 38b in information storage unit 37, the program module for the nearby facility search at step SA6 or for the route search processing may not be stored in information storage unit 37. In such case, the nearby facility search/extraction processing or route search processing is performed in an external remote information control center such as VICS, ATIS or the like which is communicatable with the navigator through the data transmission/reception device 27 of Fig. 1.

More specifically, pertinent information as to the nearby facility search conditions and route search conditions are transmitted from the navigator to the information control center. Upon request, this center conducts a search for any desired facility and/or the best possible route leading to a target place based on the search or retrieve conditions as externally transmitted. After such search is conducted, the center sends forth and provides the road guide information as to search/retrieval/extraction result along with associative map information. Upon receipt of such information, the navigator attempts to display one or a plurality of corresponding facilities. With such an arrangement, it is possible to perform a required search, retrieval and extraction of facilities based on detailed and updated information of respective facilities located around the vehicle's present position. It is also possible to render the facility search sensitive to any possible environmental changes (implementation of one-way roads, alike) in the related roads. In this case it is required that the information concerning respective facilities as stored in the remote information control center be updated every time such changes take place.

Still alternatively, the navigator may be modified such that all but the guidance/display processing at step SA5 in Fig. 9 are not always executed using the program block 38b in information storage unit 37 of Fig. 1, which may be executed by the aforesaid remote information control center such as VICS. In this case the map information may be provided by the center, rather than by the data block 38c of unit 37. In addition, the vehicle's present position detection is also carried out based on information signals being transmitted to or received from the VICS information-control center, thereby enabling the navigator to execute only the guidance/display processing based on the map information as transmitted from the VICS center. With such an arrangement, it becomes possible at any event to execute any required route search based on the updated road information and map information.

Still further, respective program modules following that of Fig. 9 and the information storage unit 37 for storage of map information and display symbol data may be separated from the navigator, which will enhance the useability by enabling a various types of devices to offer

navigation functions.

The facility marks and ID indication image components shown in Fig. 17 should not be limited exclusively to the illustrative embodiment; these may be freely changed in color, luminosity, brightness, size and shape while allowing them to at least partially blinks if needed thereby enhancing the visibility. Furthermore, the principal concepts of the present invention are capable of being also applied to vehicles other than mobiles, ships, airplanes, helicopters and others, whereas the maps used in navigation may alternatively be nautical charts, sea-bottom (submarine) maps or others, rather than the road maps.

It has been described that the illustrative embodiment is capable of performing stop-at facility search along the guidance route. Particularly, in the case of searching for along-the-path facilities located along the guidance route, respective facilities are displayed along with their relative distances as measured from the vehicle's present position This enables drivers to be aware in advance of how far a facility of interest is apart from the searched route. Further, the facility extraction conditions remain capable of being added with actual road environment of the guidance road and business content of each facility. Still further, any facility satisfying the stop-at purpose is selectable as the stop-at facility, suppressing or eliminating occurrence of any erroneous facility selection.

Moreover, the navigator is arranged to successfully determine on which side of a presently guided route the target object is located generating and issuing information as to a specific area on the decided side. This may serve to more descriptively indicate a surrounding area of the target object, enabling drivers to make a proper decision as to which side is appropriate in order to approach the target object.

A further advantage of the invention is that data capacity can be reduced due to the fact that the searching for the nearest facility is executable by use of data of landmarks available at intersection guidance. Moreover, in the situation where a specific facility involving a gas station, an eating place, etc. is under search, it is impossible in the prior art to identify the specific kind of a facility for an eating place by way of example, Japanese noodle, sushi, curry, etc. before actual arrival at the place although the user was ware of the genre of such facility; by contrast, with the present invention, the nearest facility can be successfully guided using easy-to-see diagrammatic marks thus enabling enhancement of visibility and recognizability which in turn leads to accomplishment of users' easy selection of any desired facility.

Claims

1. A navigation apparatus comprising:

   map information storage means for storing therein map information;
   target data storage means for storing guidance information as to a target object;
   present position detector means for detecting a present position of a vehicle;
   route finder means responsive to receipt of part of the map information as stored in said map information storage means, for searching for a route leading to a nearby position of the target object from one of a start point of the vehicle and a present position thereof;
   target search means for searching for a position of the target object being presently stored in said target data storage means in correspondence with the map information as stored in said map information storage means; and
   output means for providing the map information and information as to the target object as found by said target search means.

2. The apparatus according to claim 1, further comprising:

   target identifier means for determining whether the target object being presently stored in said target search means is within a predefined range from a route as searched by said route finder means, and wherein

   said output means issues information as to the target object as determined by said target identifier means.

3. The apparatus according to claim 1, further comprising:

   target identifier means for determining whether the target object searched by said target search means is within a certain range from the present position as detected by said present position detector means, and wherein

   said output means issues information concerning the target object as determined by said target identifier means.

4. A navigation apparatus comprising:

   map information memory means for storing therein map information;
   present position detector means for detecting a present position of a vehicle;
   route finder means for searching, based on the map information stored in said map information memory means, for a route leading to a nearby position of a destination from one of a position near a present position of the vehicle detected by said present position detector means and a position near a start point of the vehicle;
   target input means for allowing entry of a desired target object;

target search means for searching for an input target object entered by said target input means from the map information as stored in said map information memory means;

schematic diagram preparation means responsive to receipt of a route searched by said route finder means and a target object searched by said target search means for producing a schematic diagram indicative of a positional correlation of the route and the target object; and

output means for generating and issuing the schematic diagram provided by said schematic diagram preparation means.

5. The apparatus according to claim 4, further comprising:

distance calculation means for calculating a distance between a target object searched by said target search means and a present position of the vehicle as detected by said present position detector means, and wherein

said schematic diagram preparation means provides a schematic diagram indicative of the positional correlation of the present position and the target object based on a present position detected by said present position detector means, positional information as to the target object detected by said target search means, and a distance as calculated by said distance calculation means.

6. The apparatus according to claim 4, further comprising:

distance calculation means for determining based on said route a distance to a target object as selected by said target selector means, and wherein

said schematic diagram preparation means produces a schematic diagram representative of positional correlation of said route selected and the target object, based on the route searched by said route finder means, positional information of the target detected by said target search means and a resulting distance as calculated by said distance calculation means.

7. The apparatus according to claim 4, 5 or 6, wherein the target object along the route searched includes a target object falling within a predefined range from a route along which the vehicle has passed, and wherein one of said schematic diagram preparation means and target identifier means also deals with a target object falling within the predefined range for one of preparation of a corresponding schematic diagram and identification thereof.

8. The apparatus according to any of claims 4 to 7, further comprising:

selective target extraction means for selectively extracting a specific target object from a plurality of target objects as stored in said target search means, and for allowing selective extraction, selection and identification of the specific target object to be performed by determining whether the target object being selectively extracted is within the predefined range from the route searched.

9. The apparatus according to claim 8, wherein said selective target extraction means attempts to selectively extract the specific target object based on type, identification, classification, field, objective, use and business content of the target object, and on geographic relationship between the target object and a present position of the vehicle.

10. The apparatus according to any of claims 4 to 9, wherein said apparatus calculates a distance from the present position to a target object as identified by target identifier means, thereby generating a calculated distance to the target object by way of one of visual and audible indication schemes.

11. The apparatus according to any of claims 4 to 10, wherein said apparatus performs one of storage of a position of target object relative to the map information and a search for the position of target object relative to the map information, said search being pursuant to an external input.

12. The apparatus according to any of claims 4 to 11, said present position detector means, said target input means, said target search means, distance calculation means, said schematic diagram preparation means, target selector means, said target search means, said route finder means, target identifier means, said output means, selective target extraction means, point setter means, direction setter means, orthogonal direction setter means, target storage means, inner product calculation means and/or distance calculation means is/are a software program as stored in a recording medium, and wherein said apparatus executes processing tasks of respective means based on said program.

13. The apparatus according to any of claims 4 to 12, wherein said map information storage means, said present position detector means, said target input means, said target search means, distance calculation means, said schematic diagram preparation means, target selector means, target search means, said route finder means, target identifier means, said output means, selective target extraction means, point setter means, direction setter

means, orthogonal direction setter means, target storage means, inner product calculation means and/or distance calculation means is/are provided at a separate location excluding the vehicle, while the means absent at the separate location is/are arranged in the vehicle causing one of transmission and reception of information to be performed by communication means between the vehicle and the separate location.

14. A navigation apparatus comprising:

map information storage means for storing therein map information;
route finder means responsive to receipt of the map information stored in said map information storage means for searching for a route leading to a target point from one of a start point of a vehicle and a nearby point of a present position of the vehicle;
target search means for searching for a position of a target object in correspondence with the map information stored in said map information storage means;
target identifier means for determining on which side of a route searched by said route finder means a target object presently searched by said target search means exists; and
output means for outputting information regarding a certain side on which the target exists with respect to the route as identified by said target identifier means.

15. The apparatus according to claim 14, wherein said target identifier means includes:

reference point setter means for setting two points as reference points on a route;
orthogonal direction setter means for setting a line perpendicularly crossing with a line coupling the two points;
inner product calculation means for calculating a vector inner product of a direction being set by said orthogonal direction setter means and a target object being presently searched by said target search means based on a cross point between the two lines crossing at right angles with each other; and
said target identifier means determining in which direction the target is present from the route based on a calculation result of said inner product calculation means.

16. The apparatus according to claim 14 or 15, wherein said output means generates an identification result indicating that the target object is present on one of right side and left side of a reference line including one of the route searched by said route finder means and a reference direction as set by said direction setter means in a way corresponding to one of visual and audible indication schemes, while allowing the identification result to remain identical in one of column, size and position regardless of a distance from one of the searched route and the reference direction.

17. The apparatus according to claim 14, 15 or 16, further comprising:

distance calculation means for calculating a distance from the route searched by said route finder means to the target object searched by said target search means, and wherein said output means also generates a distance from the route to the target object as calculated by said distance calculation means.

18. The apparatus according to claim 17, wherein the distance to the target object calculated by said distance calculation means is a distance between a selected point and the target object, said selected point being near a foot of a perpendicular line to the searched route from the target object.

FIG.1

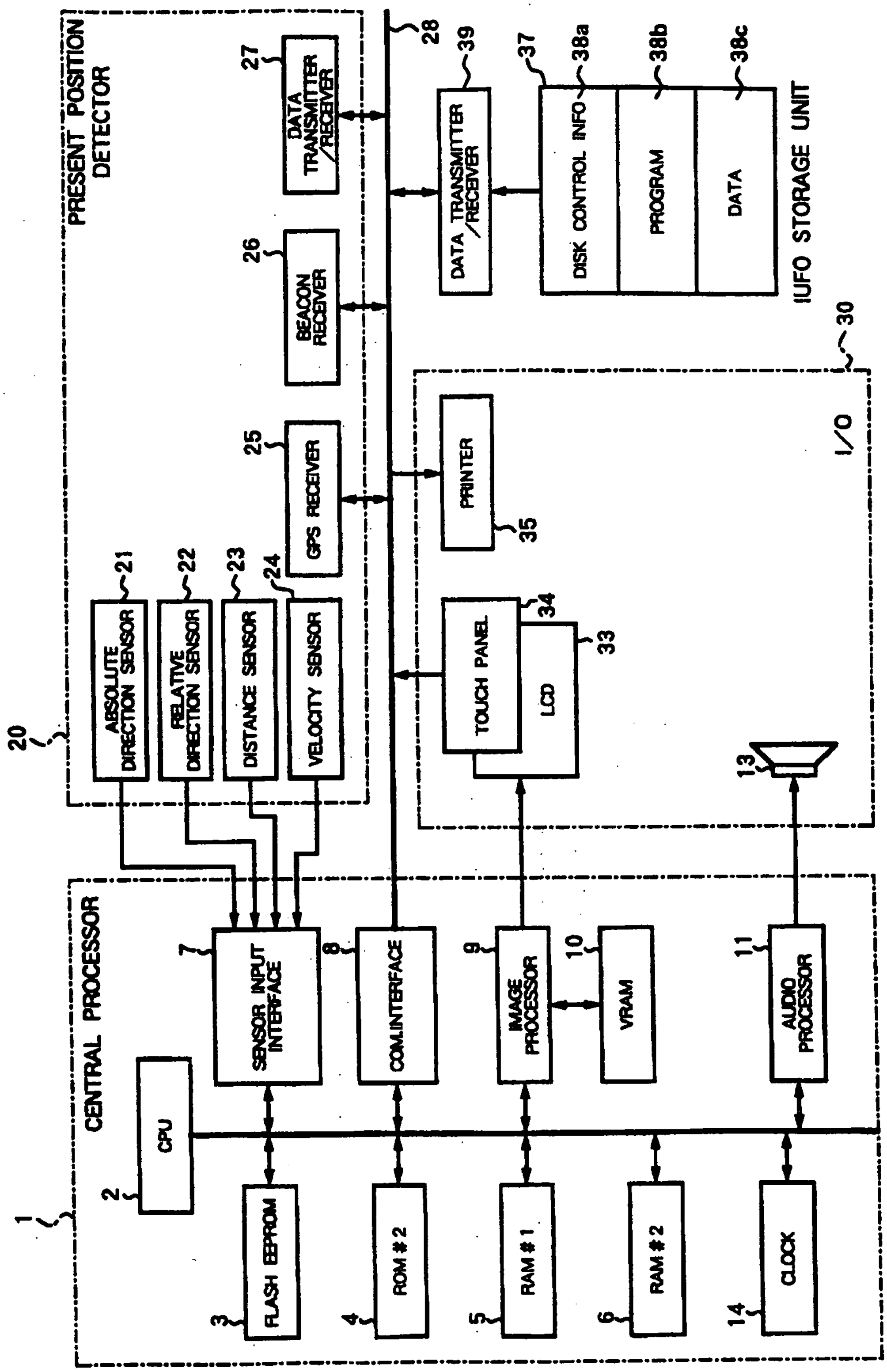

CENTRAL PROCESSOR
CPU
FLASH EEPROM
ROM # 2
RAM # 1
RAM # 2
CLOCK
SENSOR INPUT INTERFACE
COM.INTERFACE
IMAGE PROCESSOR
VRAM
AUDIO PROCESSOR
PRESENT POSITION DETECTOR
ABSOLUTE DIRECTION SENSOR
RELATIVE DIRECTION SENSOR
DISTANCE SENSOR
VELOCITY SENSOR
GPS RECEIVER
BEACON RECEIVER
DATA TRANSMITTER /RECEIVER
TOUCH PANEL
LCD
PRINTER
I/O
DATA TRANSMITTER /RECEIVER
DISK CONTROL INFO
PROGRAM
DATA
IUFO STORAGE UNIT
1
2
3
4
5
6
7
8
9
10
11
13
14
20
21
22
23
24
25
26
27
28
30
33
34
35
37
38a
38b
38c
39

FIG.2

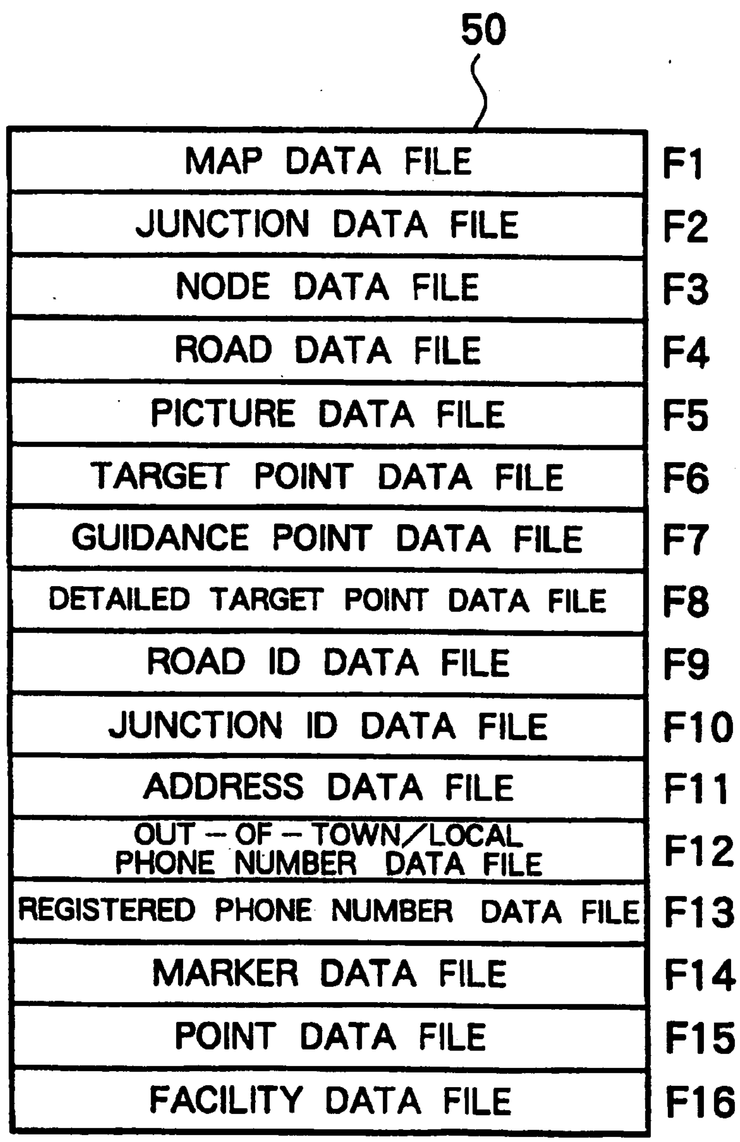

50
MAP DATA FILE
F1
JUNCTION DATA FILE
F2
NODE DATA FILE
F3
ROAD DATA FILE
F4
PICTURE DATA FILE
F5
TARGET POINT DATA FILE
F6
GUIDANCE POINT DATA FILE
F7
DETAILED TARGET POINT DATA FILE
F8
ROAD ID DATA FILE
F9
JUNCTION ID DATA FILE
F10
ADDRESS DATA FILE
F11
OUT – OF – TOWN/LOCAL PHONE NUMBER DATA FILE
F12
REGISTERED PHONE NUMBER DATA FILE
F13
MARKER DATA FILE
F14
POINT DATA FILE
F15
FACILITY DATA FILE
F16

FIG.3

F16

FACILITY DATA FILE

	FACILITY NUMBER SS (n)
	GENRE NUMBER
	EAST LONGITUDE COORDINATES SEO
1	NORTH LATITUDE COORDINATES SNO
	MARK NUMBER SPN
	NAME SN
	⋮
	GENRE NUMBER SJN
	EAST LONGITUDE COORDINATES SEO
n	NORTH LATITUDE COORDINATES SNO
	MARK NUMBER SPN
	NAME SN

FIG.4

5

RAM # 1

PRESENT POSITION DATA MP
ABSOLUTE DIRECTION DATA ZD
RELATIVE DIRECTION DATA D θ
RUNNING DISTANCE DATA ML
PRESENT POSITION INFO PI
VICS DATA VD
ATIS DATA AD
REGISTERED TARGET POINT DATA TP
GUIDANCE START POINT DATA SP
FINAL GUIDANCE POINT DATA ED
GUIDANCE ROUTE DATA MW
MODE SET DATA MD
BEEP POINT DATA BP
SEARCH FACILITY NO. GBn (n = 1、…)
FACILITY – TO – TARGET POINT DISTANCE Zn
VEHICLE – TO – FACILITY DISTANCE Wn
FACILITY – TO – DISTANCE Rmin
RIGHT／LEFT RL

FIG.5

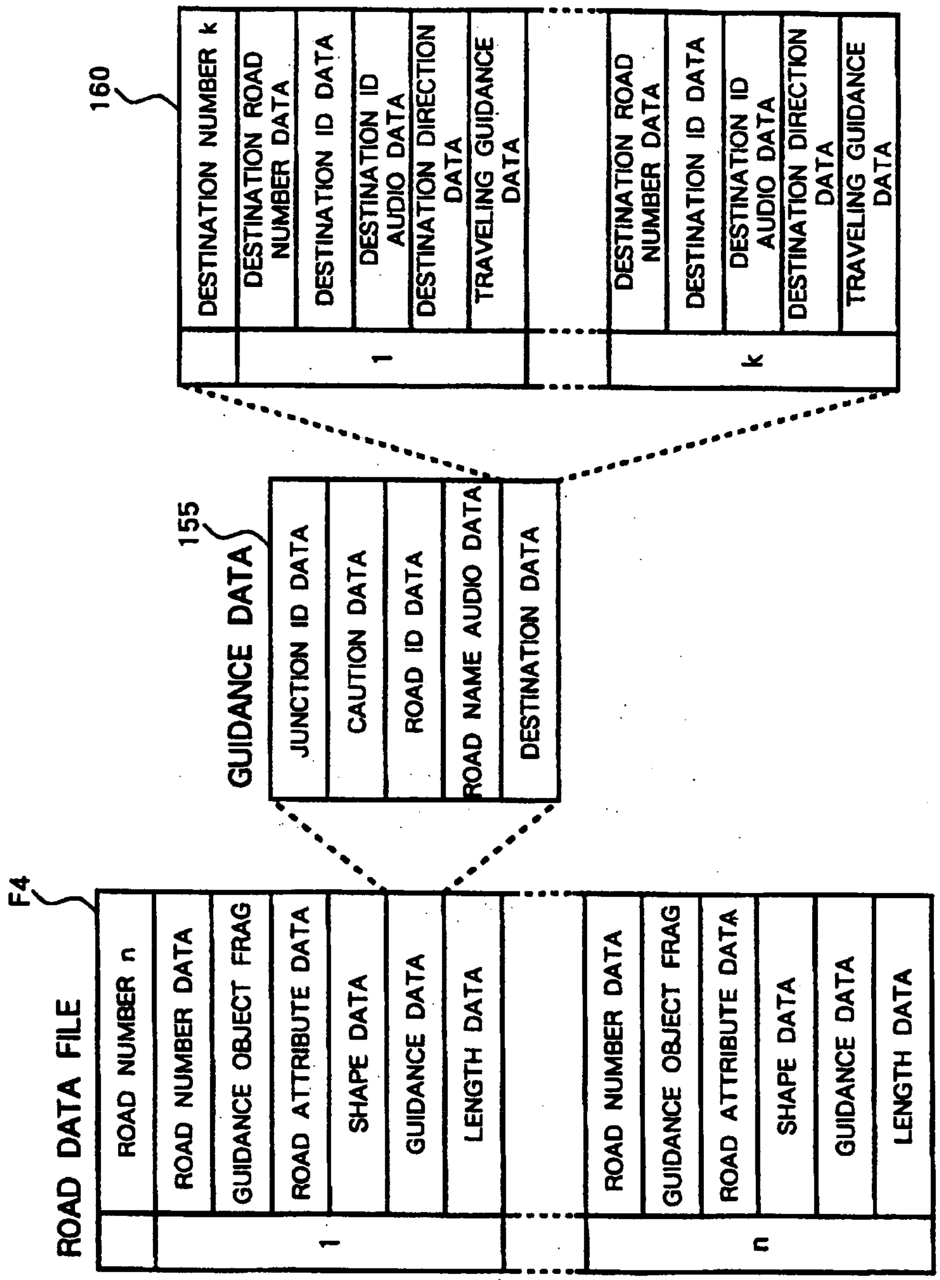

ROAD DATA FILE
F4
1
ROAD NUMBER n
ROAD NUMBER DATA
GUIDANCE OBJECT FRAG
ROAD ATTRIBUTE DATA
SHAPE DATA
GUIDANCE DATA
LENGTH DATA
n
ROAD NUMBER DATA
GUIDANCE OBJECT FRAG
ROAD ATTRIBUTE DATA
SHAPE DATA
GUIDANCE DATA
LENGTH DATA
GUIDANCE DATA
155
JUNCTION ID DATA
CAUTION DATA
ROAD ID DATA
ROAD NAME AUDIO DATA
DESTINATION DATA
160
1
DESTINATION NUMBER k
DESTINATION ROAD NUMBER DATA
DESTINATION ID DATA
DESTINATION ID AUDIO DATA
DESTINATION DIRECTION DATA
TRAVELING GUIDANCE DATA
k
DESTINATION ROAD NUMBER DATA
DESTINATION ID DATA
DESTINATION ID AUDIO DATA
DESTINATION DIRECTION DATA
TRAVELING GUIDANCE DATA

FIG.6

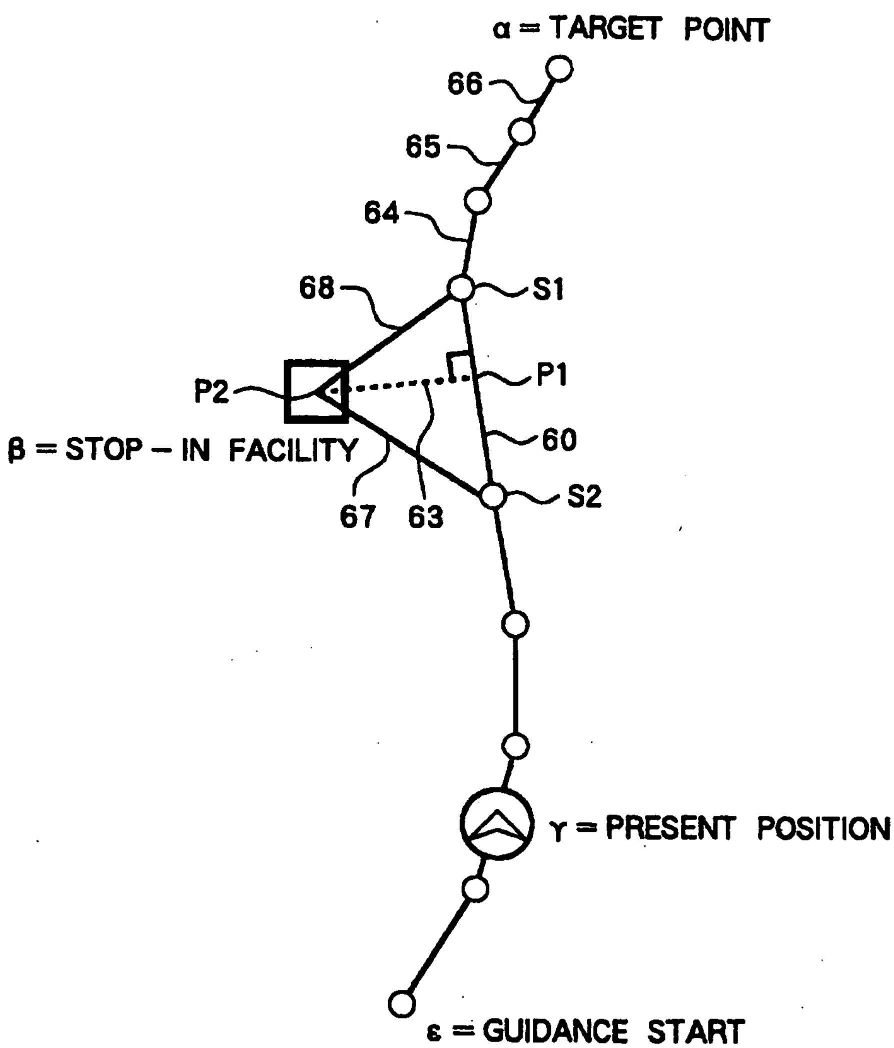

α = TARGET POINT
66
65
64
68
S1
P1
P2
60
β = STOP – IN FACILITY
67
63
S2
γ = PRESENT POSITION
ε = GUIDANCE START

FIG.7

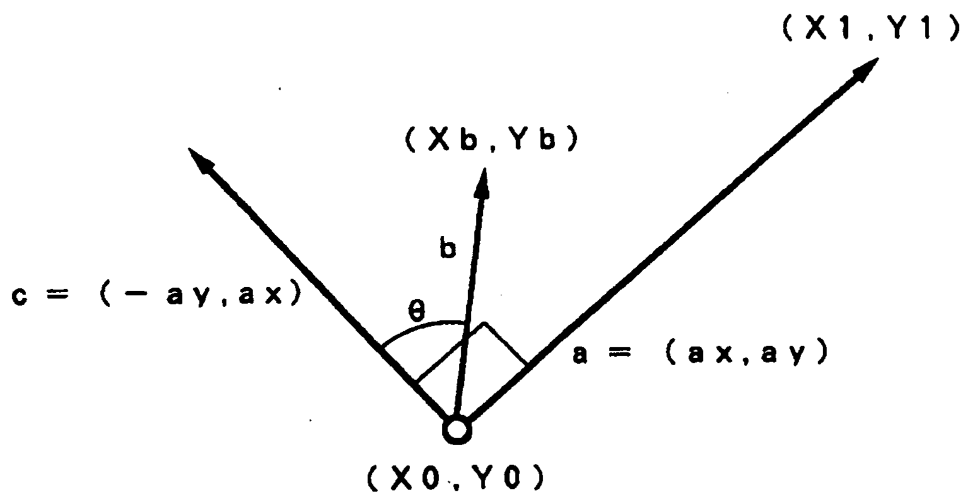


FIG.8

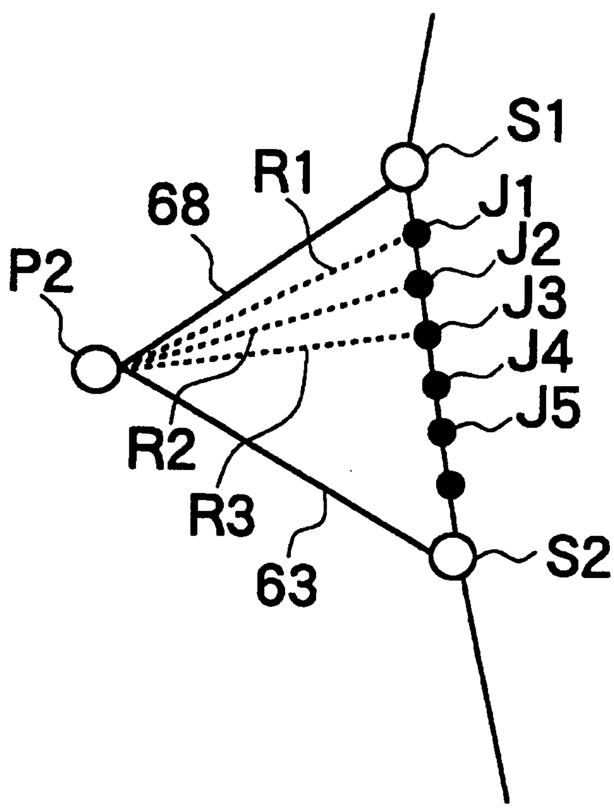


FIG.9

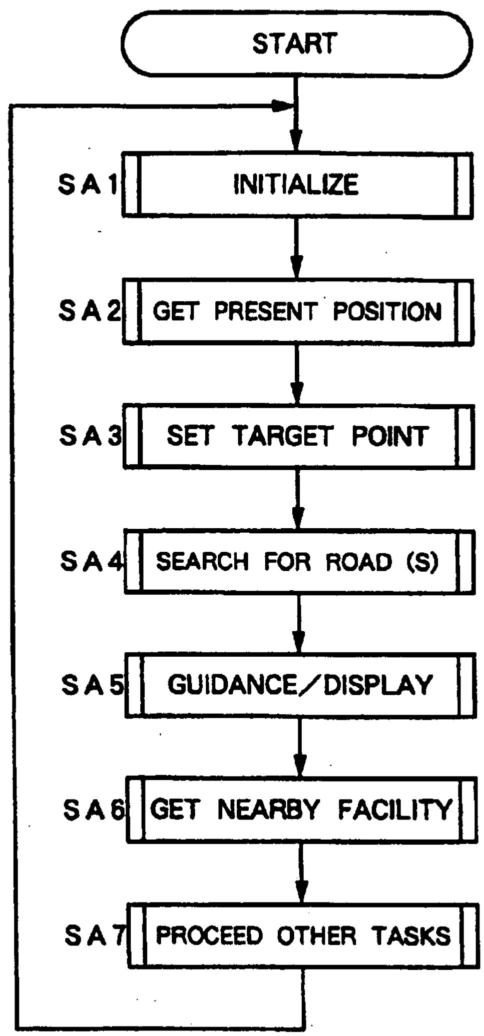

START
SA1
INITIALIZE
SA2
GET PRESENT POSITION
SA3
SET TARGET POINT
SA4
SEARCH FOR ROAD (S)
SA5
GUIDANCE/DISPLAY
SA6
GET NEARBY FACILITY
SA7
PROCEED OTHER TASKS

FIG.10

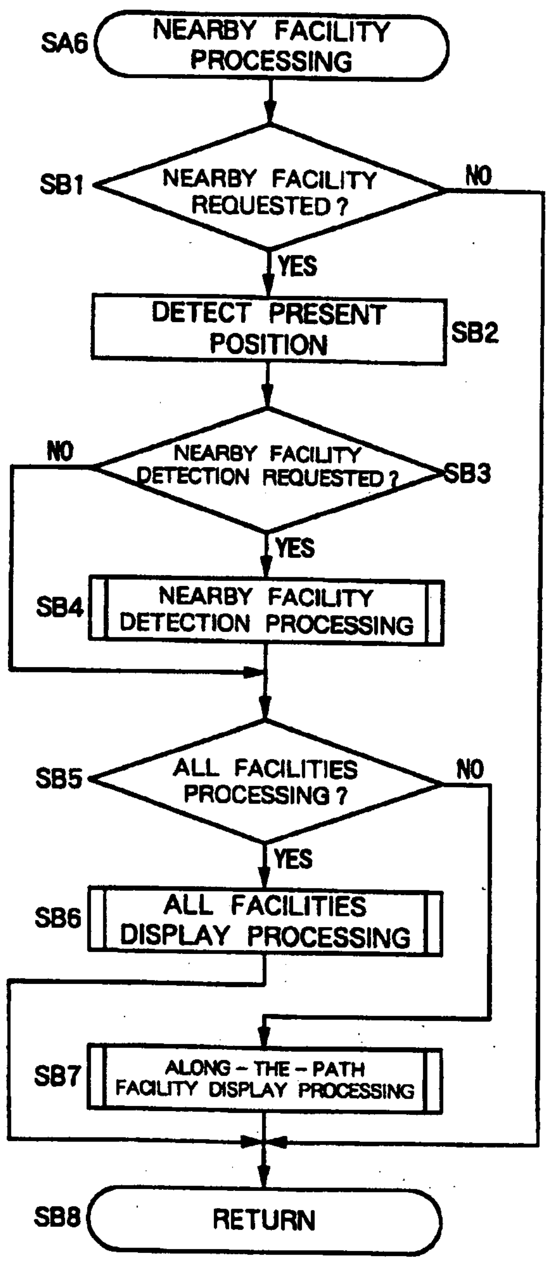

SA6
NEARBY FACILITY PROCESSING
SB1
NEARBY FACILITY REQUESTED ?
NO
YES
DETECT PRESENT POSITION
SB2
NO
NEARBY FACILITY DETECTION REQUESTED ?
SB3
YES
SB4
NEARBY FACILITY DETECTION PROCESSING
SB5
ALL FACILITIES PROCESSING ?
NO
YES
SB6
ALL FACILITIES DISPLAY PROCESSING
SB7
ALONG - THE - PATH FACILITY DISPLAY PROCESSING
SB8
RETURN

FIG.11

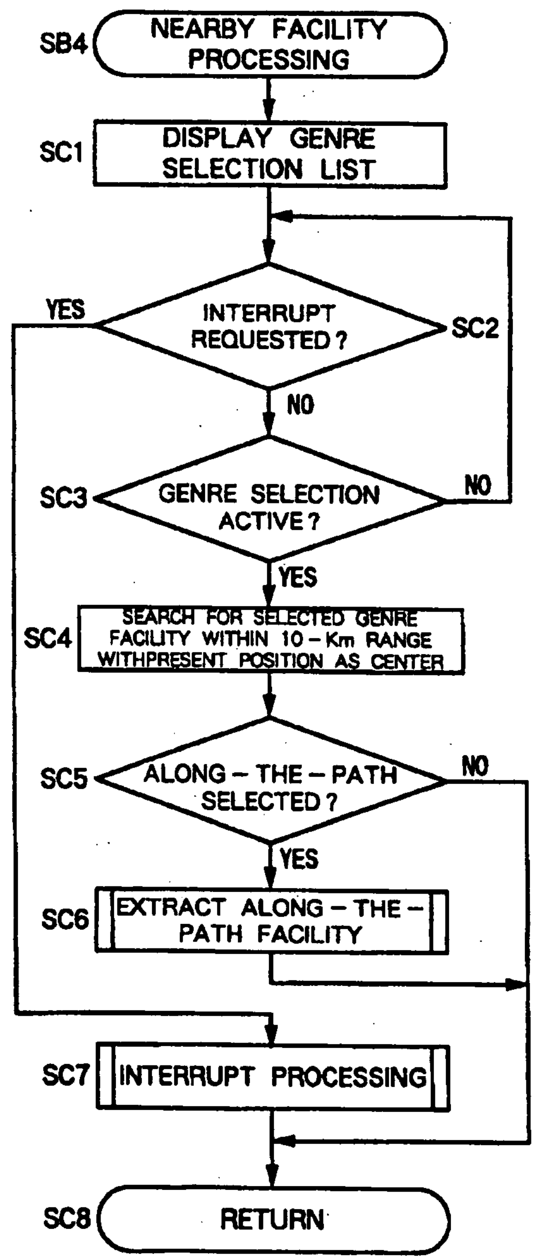

SB4
NEARBY FACILITY PROCESSING
SC1
DISPLAY GENRE SELECTION LIST
YES
INTERRUPT REQUESTED ?
SC2
NO
SC3
GENRE SELECTION ACTIVE ?
NO
YES
SC4
SEARCH FOR SELECTED GENRE FACILITY WITHIN 10 - Km RANGE WITHPRESENT POSITION AS CENTER
SC5
ALONG - THE - PATH SELECTED ?
NO
YES
SC6
EXTRACT ALONG - THE - PATH FACILITY
SC7
INTERRUPT PROCESSING
SC8
RETURN

FIG.12

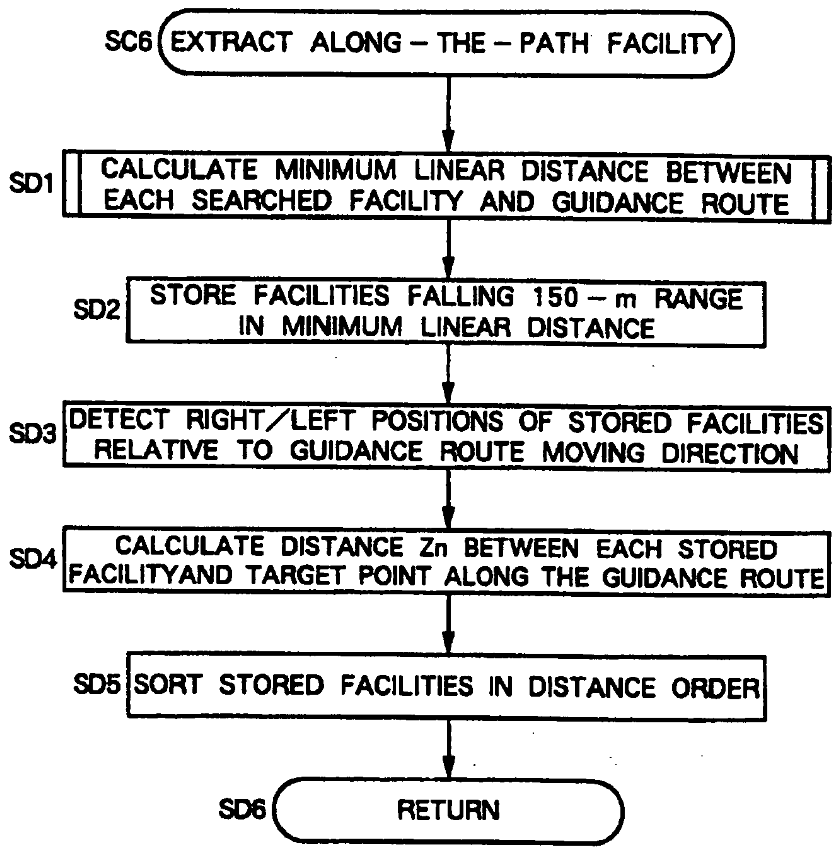

SC6 EXTRACT ALONG – THE – PATH FACILITY
SD1 CALCULATE MINIMUM LINEAR DISTANCE BETWEEN EACH SEARCHED FACILITY AND GUIDANCE ROUTE
SD2 STORE FACILITIES FALLING 150 – m RANGE IN MINIMUM LINEAR DISTANCE
SD3 DETECT RIGHT/LEFT POSITIONS OF STORED FACILITIES RELATIVE TO GUIDANCE ROUTE MOVING DIRECTION
SD4 CALCULATE DISTANCE Zn BETWEEN EACH STORED FACILITYAND TARGET POINT ALONG THE GUIDANCE ROUTE
SD5 SORT STORED FACILITIES IN DISTANCE ORDER
SD6 RETURN

FIG.13

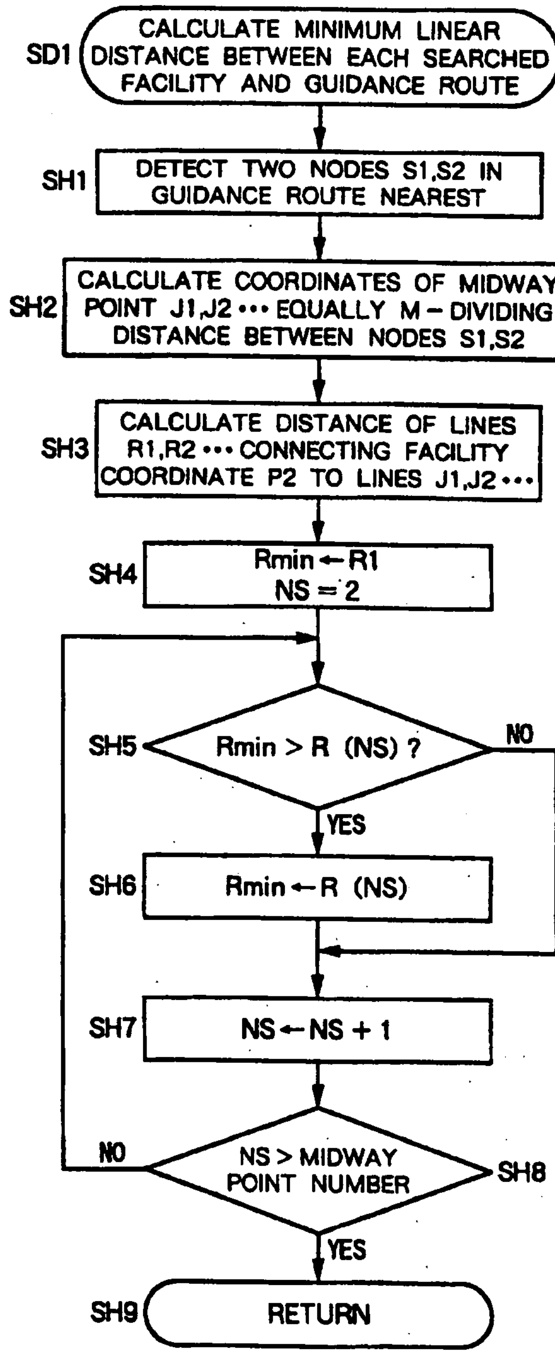

SD1
CALCULATE MINIMUM LINEAR DISTANCE BETWEEN EACH SEARCHED FACILITY AND GUIDANCE ROUTE
SH1
DETECT TWO NODES S1,S2 IN GUIDANCE ROUTE NEAREST
SH2
CALCULATE COORDINATES OF MIDWAY POINT J1,J2 ••• EQUALLY M – DIVIDING DISTANCE BETWEEN NODES S1,S2
SH3
CALCULATE DISTANCE OF LINES R1,R2 ••• CONNECTING FACILITY COORDINATE P2 TO LINES J1,J2 •••
SH4
Rmin ← R1
NS = 2
SH5
Rmin > R (NS) ?
NO
YES
SH6
Rmin ← R (NS)
SH7
NS ← NS + 1
NO
NS > MIDWAY POINT NUMBER
SH8
YES
SH9
RETURN

FIG.14

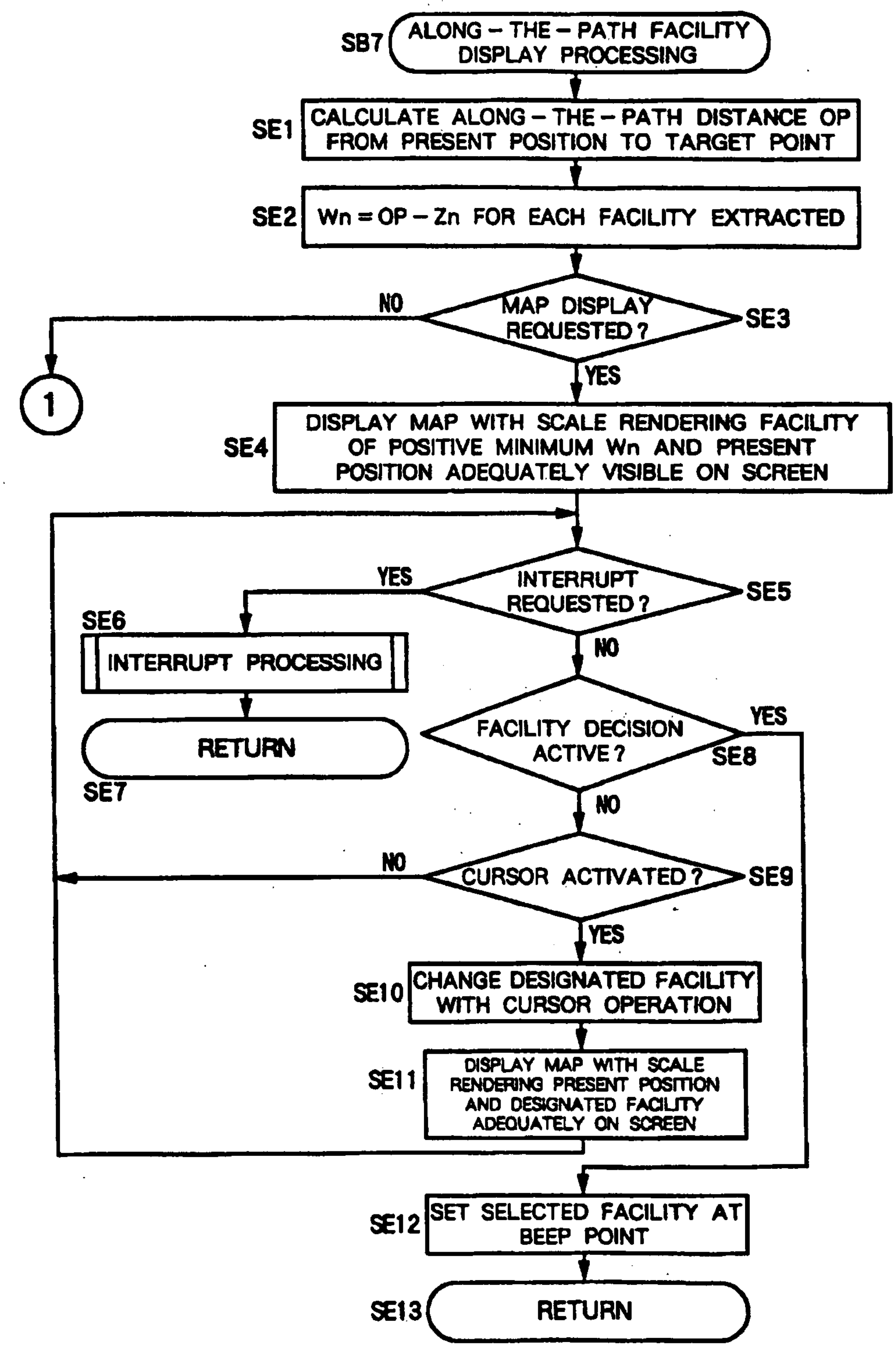

SB7
ALONG-THE-PATH FACILITY DISPLAY PROCESSING
SE1
CALCULATE ALONG-THE-PATH DISTANCE OP FROM PRESENT POSITION TO TARGET POINT
SE2
Wn = OP - Zn FOR EACH FACILITY EXTRACTED
MAP DISPLAY REQUESTED ?
SE3
NO
YES
1
SE4
DISPLAY MAP WITH SCALE RENDERING FACILITY OF POSITIVE MINIMUM Wn AND PRESENT POSITION ADEQUATELY VISIBLE ON SCREEN
INTERRUPT REQUESTED ?
SE5
YES
NO
SE6
INTERRUPT PROCESSING
RETURN
SE7
FACILITY DECISION ACTIVE ?
SE8
YES
NO
CURSOR ACTIVATED ?
SE9
NO
YES
SE10
CHANGE DESIGNATED FACILITY WITH CURSOR OPERATION
SE11
DISPLAY MAP WITH SCALE RENDERING PRESENT POSITION AND DESIGNATED FACILITY ADEQUATELY ON SCREEN
SE12
SET SELECTED FACILITY AT BEEP POINT
SE13
RETURN

FIG.15

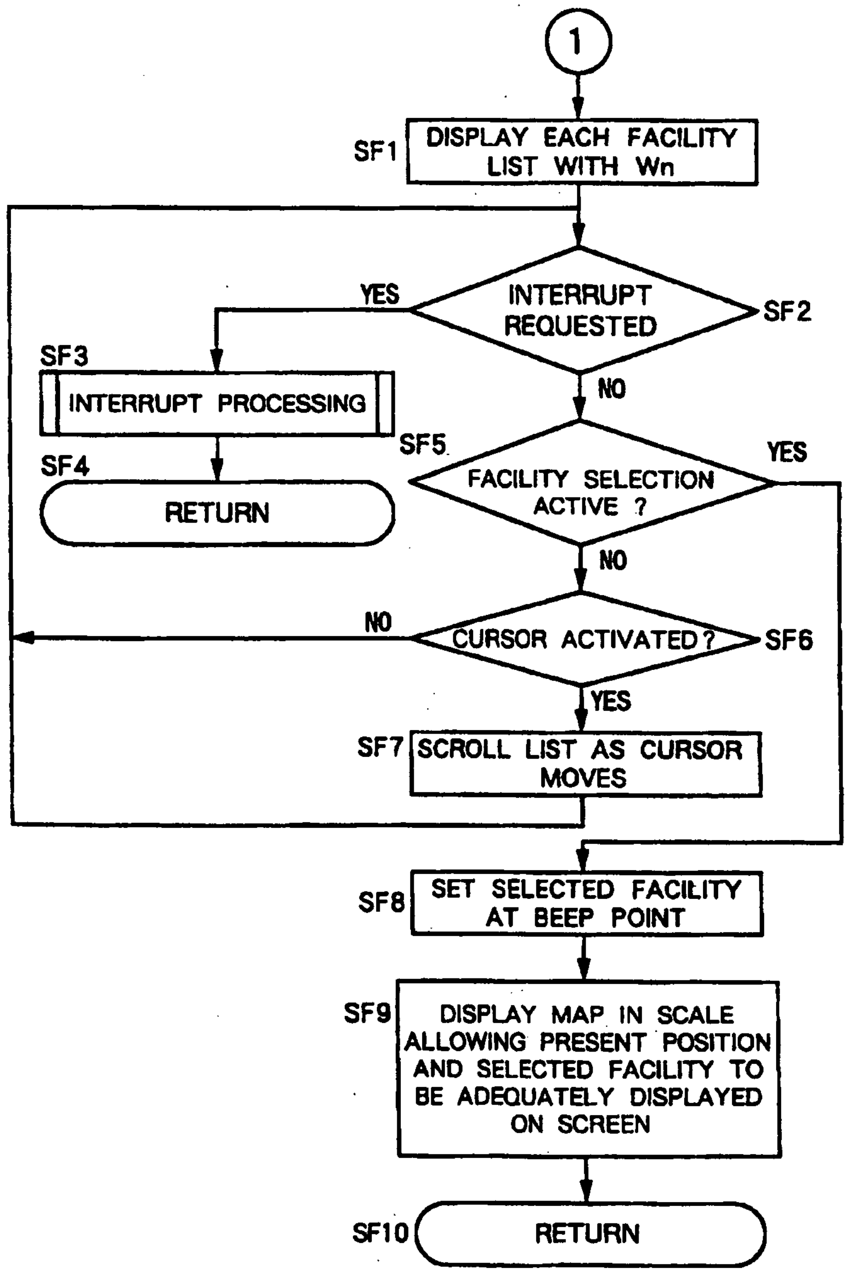

1
SF1
DISPLAY EACH FACILITY LIST WITH Wn
YES
INTERRUPT REQUESTED
SF2
SF3
INTERRUPT PROCESSING
NO
SF5
YES
SF4
FACILITY SELECTION ACTIVE ?
RETURN
NO
NO
CURSOR ACTIVATED?
SF6
YES
SF7
SCROLL LIST AS CURSOR MOVES
SF8
SET SELECTED FACILITY AT BEEP POINT
SF9
DISPLAY MAP IN SCALE ALLOWING PRESENT POSITION AND SELECTED FACILITY TO BE ADEQUATELY DISPLAYED ON SCREEN
SF10
RETURN

FIG.16

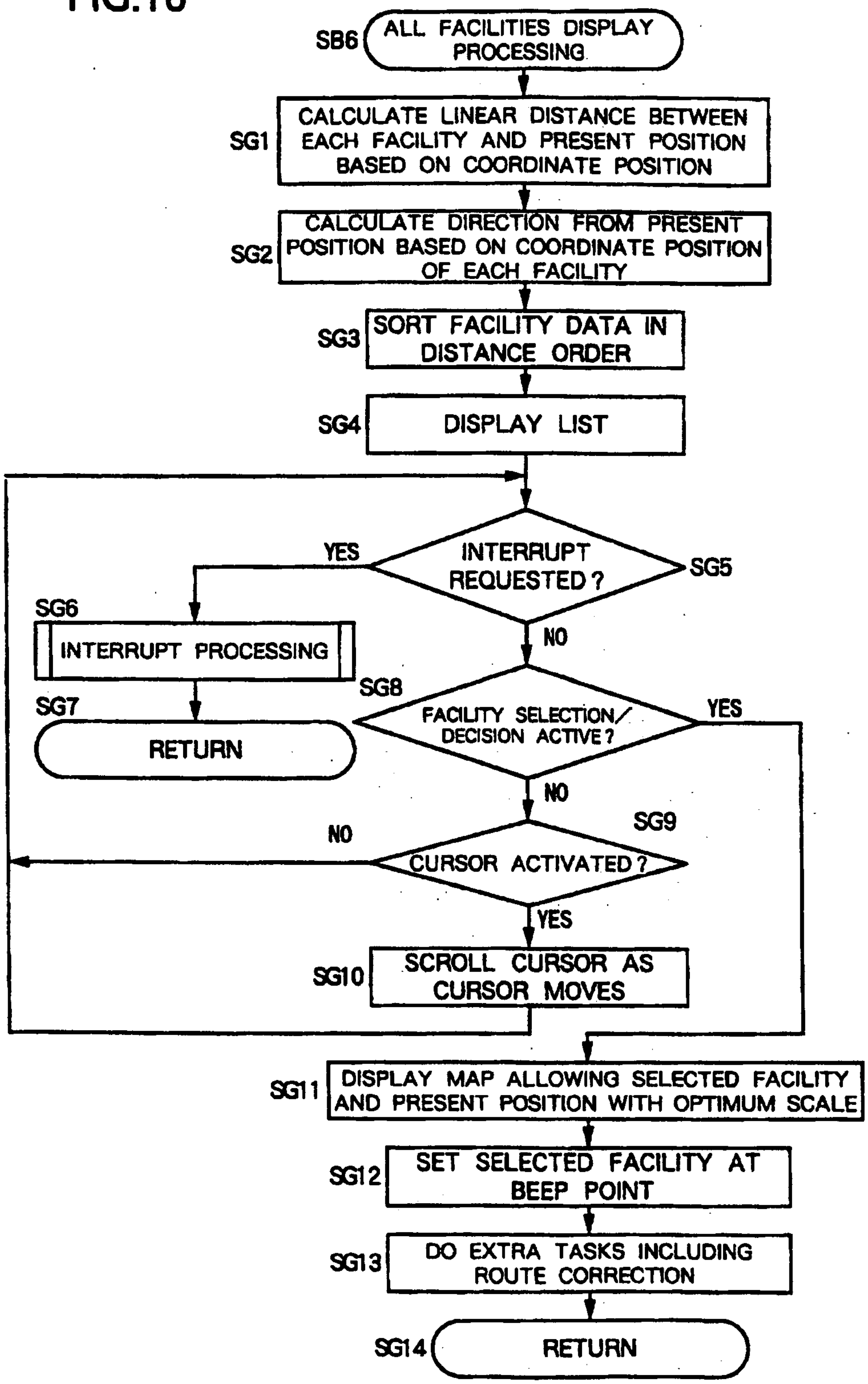

SB6
ALL FACILITIES DISPLAY PROCESSING
SG1
CALCULATE LINEAR DISTANCE BETWEEN EACH FACILITY AND PRESENT POSITION BASED ON COORDINATE POSITION
SG2
CALCULATE DIRECTION FROM PRESENT POSITION BASED ON COORDINATE POSITION OF EACH FACILITY
SG3
SORT FACILITY DATA IN DISTANCE ORDER
SG4
DISPLAY LIST
SG5
INTERRUPT REQUESTED ?
YES
NO
SG6
INTERRUPT PROCESSING
SG7
RETURN
SG8
FACILITY SELECTION/ DECISION ACTIVE ?
YES
NO
SG9
CURSOR ACTIVATED ?
NO
YES
SG10
SCROLL CURSOR AS CURSOR MOVES
SG11
DISPLAY MAP ALLOWING SELECTED FACILITY AND PRESENT POSITION WITH OPTIMUM SCALE
SG12
SET SELECTED FACILITY AT BEEP POINT
SG13
DO EXTRA TASKS INCLUDING ROUTE CORRECTION
SG14
RETURN

FIG.17

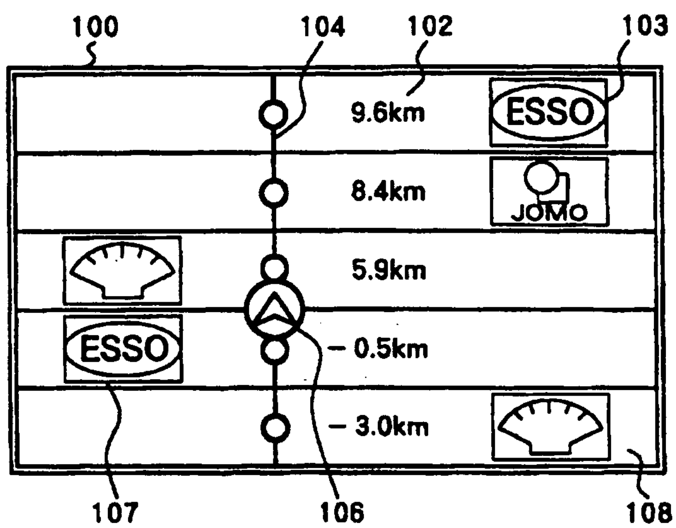

100
104
102
103
9.6km
ESSO
8.4km
JOMO
5.9km
ESSO
– 0.5km
– 3.0km
107
106
108

FIG.18

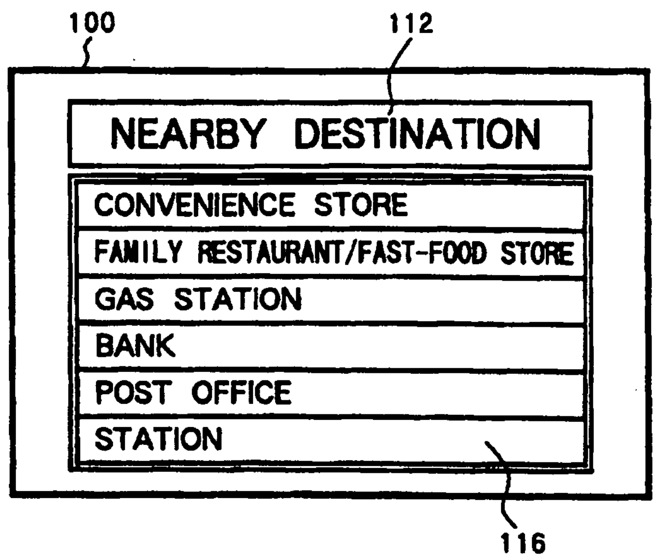

100
112
NEARBY DESTINATION
CONVENIENCE STORE
FAMILY RESTAURANT/FAST-FOOD STORE
GAS STATION
BANK
POST OFFICE
STATION
116

FIG.19

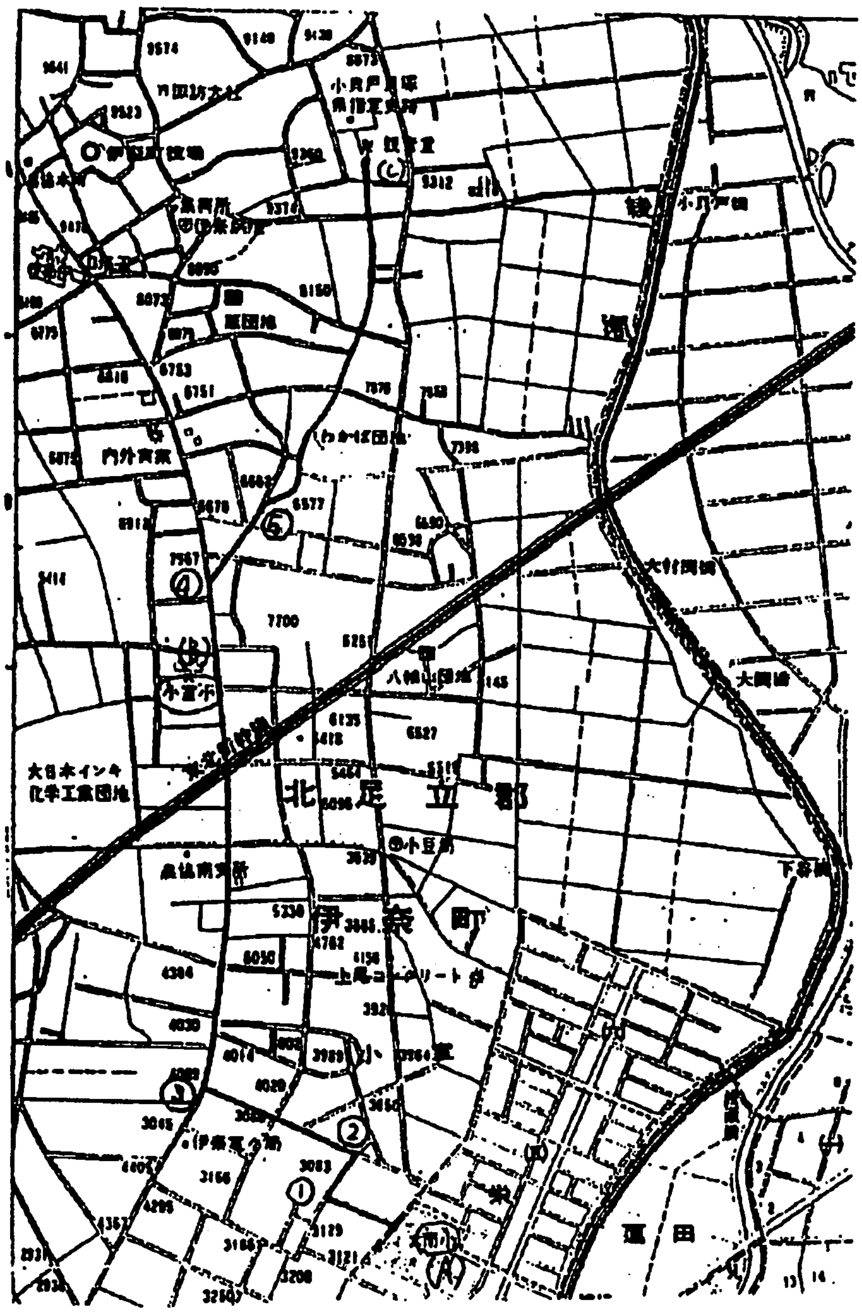


FIG.20a

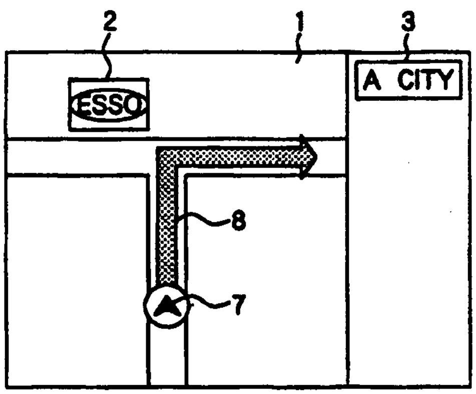


FIG.20b

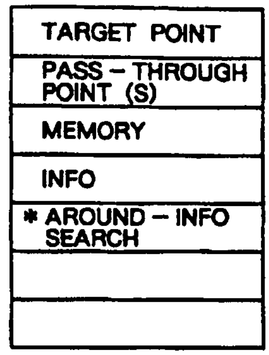


FIG.20c

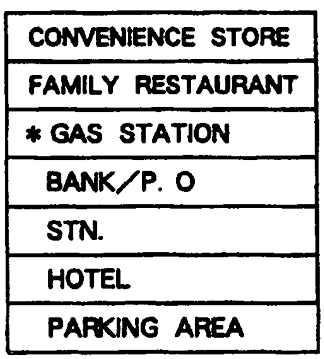


FIG.20d

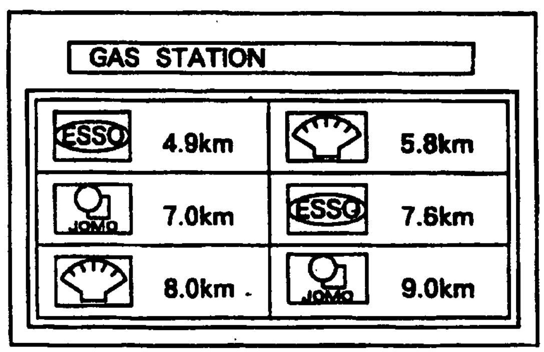


FIG.21

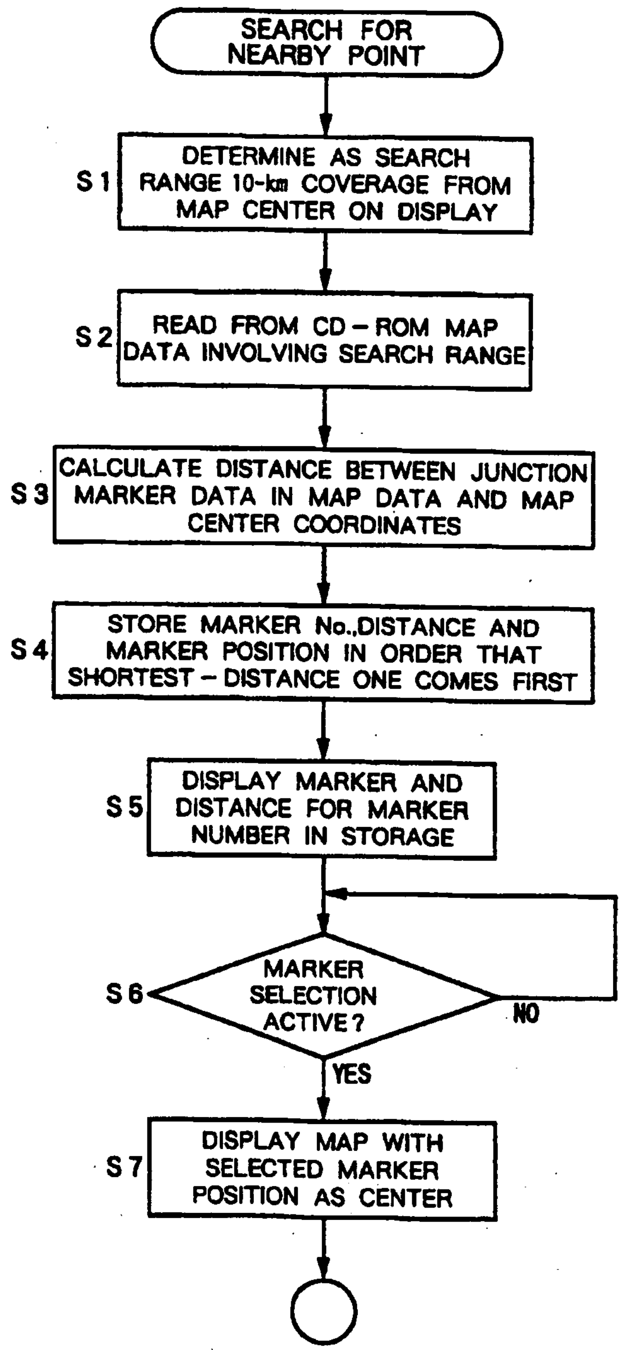

SEARCH FOR NEARBY POINT
S 1
DETERMINE AS SEARCH RANGE 10-km COVERAGE FROM MAP CENTER ON DISPLAY
S 2
READ FROM CD-ROM MAP DATA INVOLVING SEARCH RANGE
S 3
CALCULATE DISTANCE BETWEEN JUNCTION MARKER DATA IN MAP DATA AND MAP CENTER COORDINATES
S 4
STORE MARKER No.,DISTANCE AND MARKER POSITION IN ORDER THAT SHORTEST-DISTANCE ONE COMES FIRST
S 5
DISPLAY MARKER AND DISTANCE FOR MARKER NUMBER IN STORAGE
S 6
MARKER SELECTION ACTIVE?
NO
YES
S 7
DISPLAY MAP WITH SELECTED MARKER POSITION AS CENTER

FIG.22

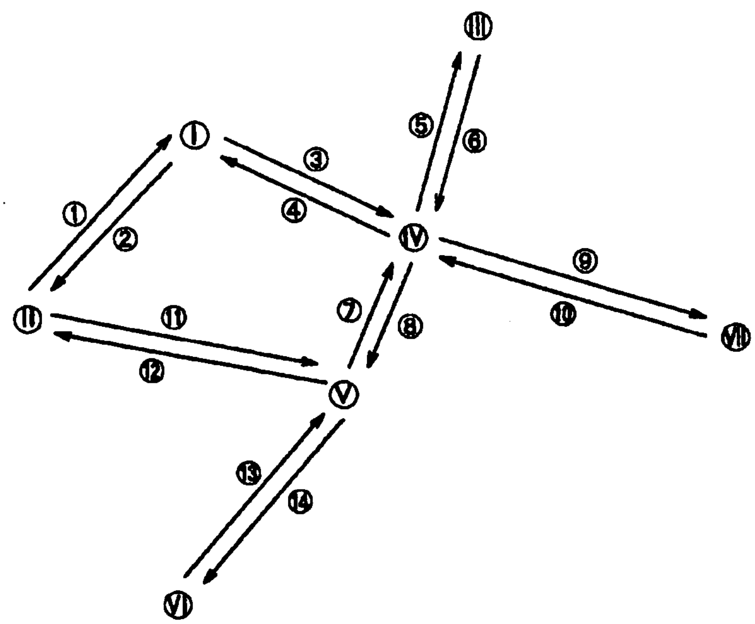


FIG.23a
JUNCTION DATA

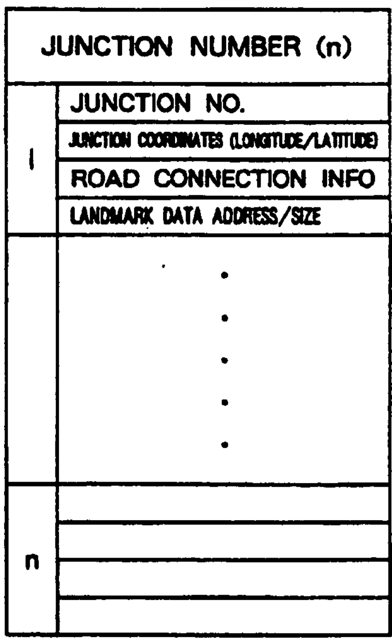


FIG.23b
LANDMARK DATA

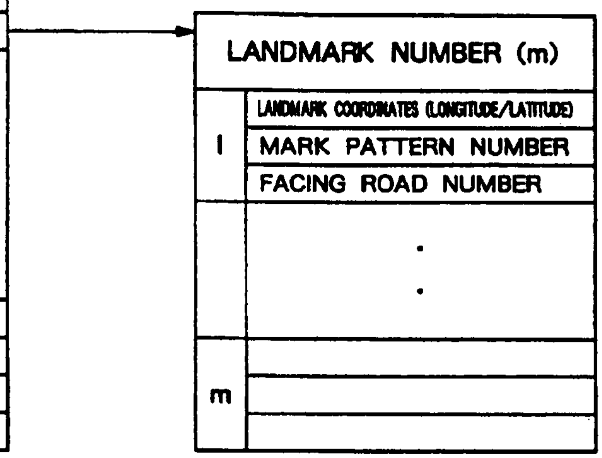


FIG.23c
MARK PATTERN DATA

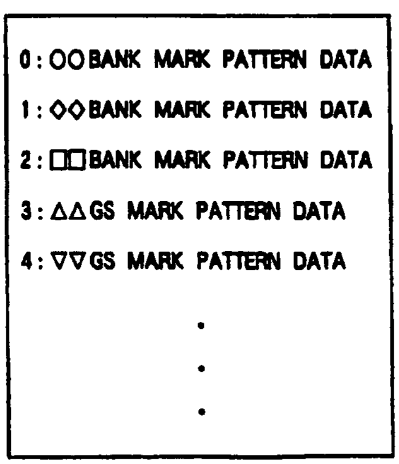


FIG.23d
LANDMARK DATA

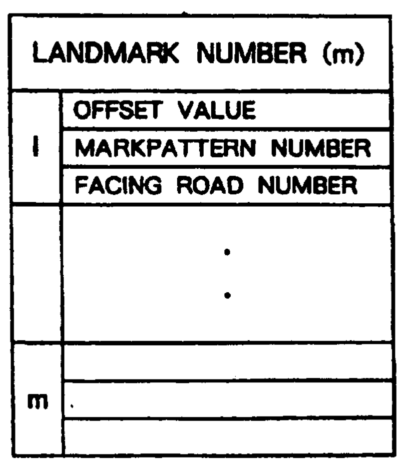


FIG.24

ROAD No.	NEXT ROAD No. WITH SAME START POINT	NEXT ROAD No. WITH SAME END POINT	START POINT	END POINT	NODE ARRAY POINTER	ROAD LENGTH	LAND MARK No.
①	⑪	④	II	I	A000	1000	
②	③	⑫	I	II	A0A0	1000	
③	②	⑥	I	IV	A0B3	2000	
④	⑤	①	IV	I	A0C0	2000	
⑤	⑧	⑤	IV	III	A0DE	1500	
⑥	⑥	⑦	III	IV	A101	1500	
⑦	⑫	⑩	V	IV	A201	800	
⑧	⑨	⑪	IV	V	A221	800	
⑨	④	⑨	IV	VII	A253		
⑩	⑩	③	VII	IV	A260		
⑪	①	⑬	II	V	A265		
⑫	⑭	②	V	II	A28B		
⑬	⑬	⑧	VI	V	A2A0		
⑭	⑦	⑭	V	VI	A2B0		

FIG.25a

GUIDANCE ROAD DATA

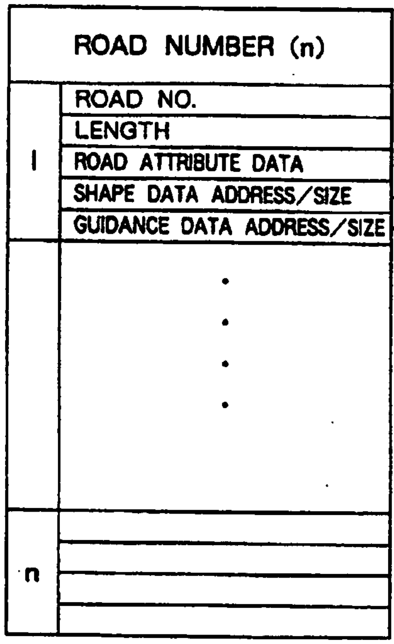


FIG.25c

SHAPE DATA

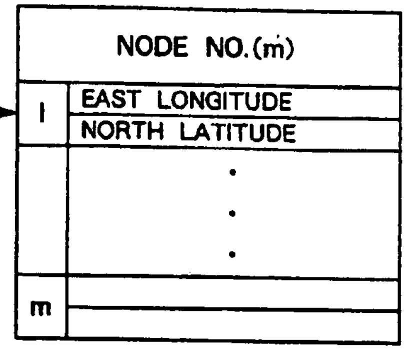


FIG.25c

GUIDANCE DATA

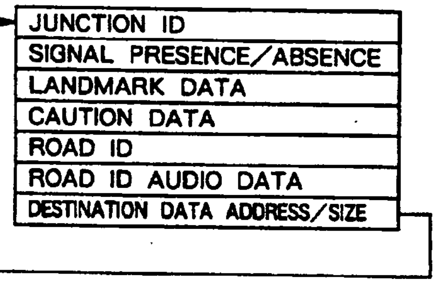


FIG.25d

DESTINATION DATA

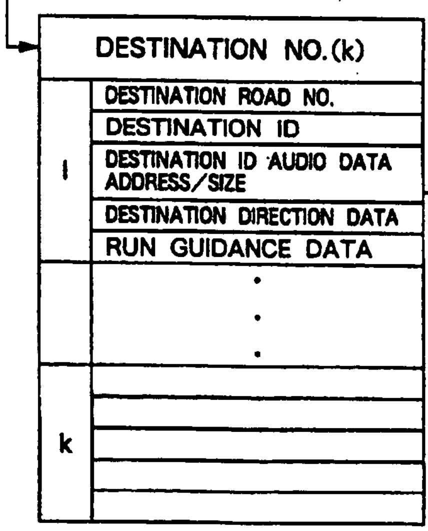


FIG.25e

DESTINATION DIRECTION DATA

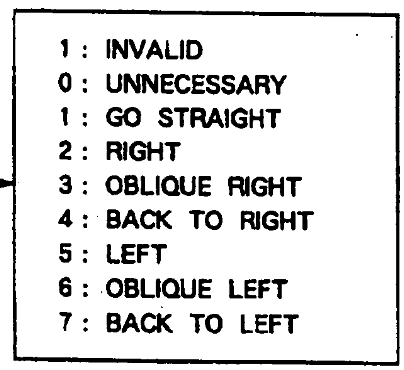


FIG.26a

ROAD ATTRIBUTE DATA

PRESENCE/ABSENCE INFO
PRESENT : O

ELEVATED TRACK/ SUBWAY ROAD DATA	ELEVATED TRACK	
	BESIDE ELEVATED TRACK	
	SUBWAY ROAD	O
	BESIDE SUBWAY ROAD	
LANE NO.	MORE THAN THREE LANES	
	TWO LANES	O
	SINGLE LANE	
	NO CENTER LINE	

FIG.26b

ROAD ID DATA

ROAD TYPE	TYPE NO.

	HIGHWAY	MAIN	1
		ACCESS	2
	CITY SPEED WAY	MAIN	3
		ACCESS	4
	TOLL ROAD	MAIN	5
		ACCESS	6
PUBLIC ROADS	NATIONAL ROAD		7
	PREFECTURAL ROAD		8
	OTHERS		9

FIG.26c

CAUTION DATA

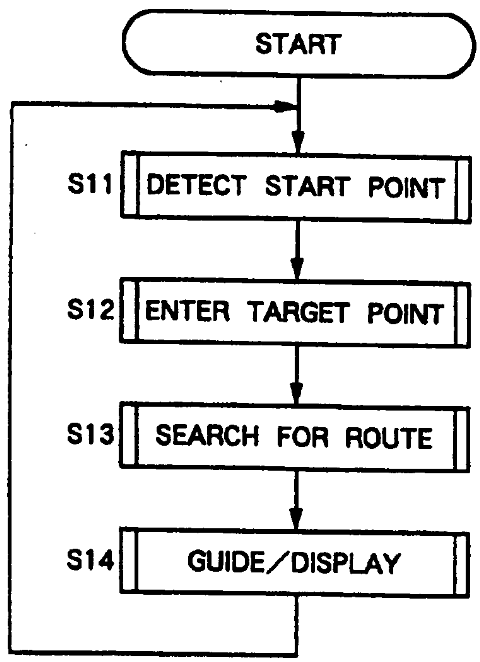
RAILROAD CROSSING	O
TUNNEL ENTRANCE	
TUNNEL EXIT	
WIDTH DECREASE POINT	
NONE	

FIG.26d

GUIDANCE DATA

FROM RIGHT	
FROM LEFT	
PROM CENTER	O
NONE	

FIG.27


START
S11
DETECT START POINT
S12
ENTER TARGET POINT
S13
SEARCH FOR ROUTE
S14
GUIDE/DISPLAY

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 11 5833

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP-A-0 638 887 (TOYOTA MOTOR CO LTD) 15 February 1995 * the whole document * ---	1,4,14	G01C21/20
A	EP-A-0 539 143 (PIONEER ELECTRONIC CORP) 28 April 1993 * the whole document * ---	1,4,14	
A	EP-A-0 419 248 (LASER DATA TECHNOLOGY INC) 27 March 1991 * the whole document * ---	1,4,14	
A	PROCEEDINGS OF THE VEHICLE NAVIGATION AND INFORMATION SYSTEMS CONFERENCE. (VNIS), TORONTO, SEPT. 11 - 13, 1989, no. CONF. 1, 11 September 1989, REEKIE D;CASE E; TSAI J, pages 85-88, XP000233016 FRANK D L: "INFORMATION SYSTEMS: AN INTEGRAL PART OF FUTURE VEHICLES" * the whole document * -----	1,4,14	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

G01C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13 January 1997	Hoekstra, F

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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